Meteosat Flow Forecasting & Drought Monitoring

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EARS Earth Environment Monitoring BV

Delft, The Netherlands

EARS Earth Environment Monitoring BV

- Remote sensing company since 1977
- Delft, the Netherlands
- Energy & Water Balance Monitoring
- Using geostationary meteorological satellites
- Climate, Water and Food applications:

✓ *River flow forecasting*

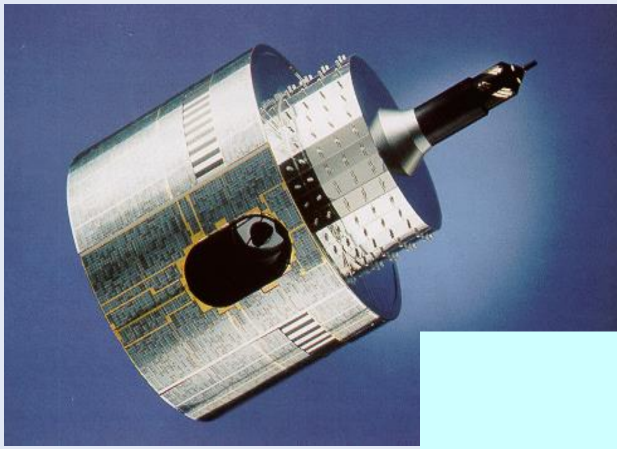
✓ *Drought monitoring*

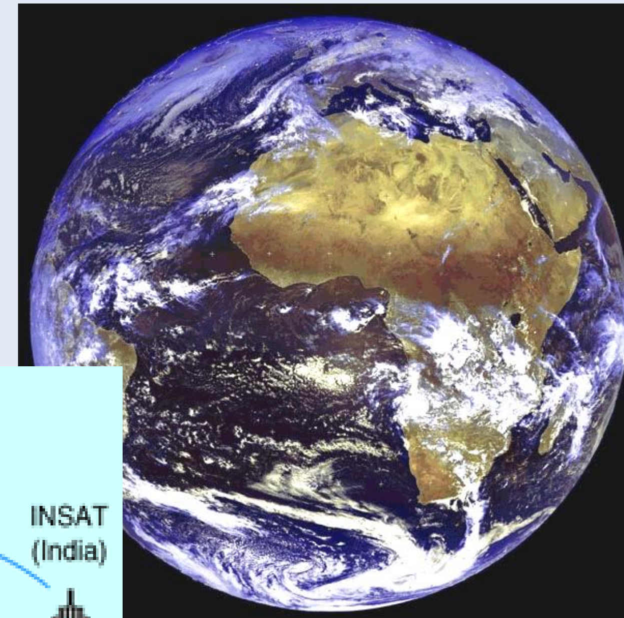
✓ *Crop yield forecasting*

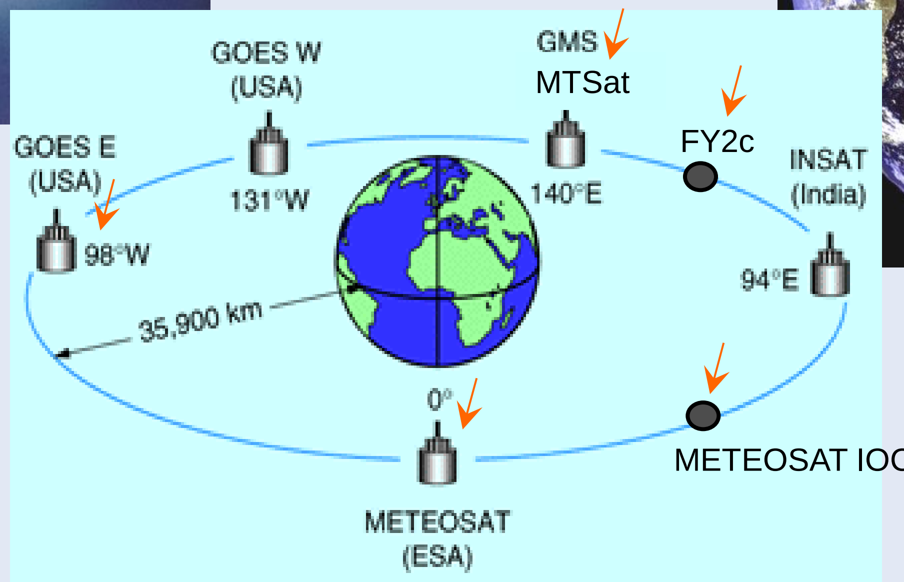
✓ *Crop insurance*

Energy and Water Balance Monitoring System

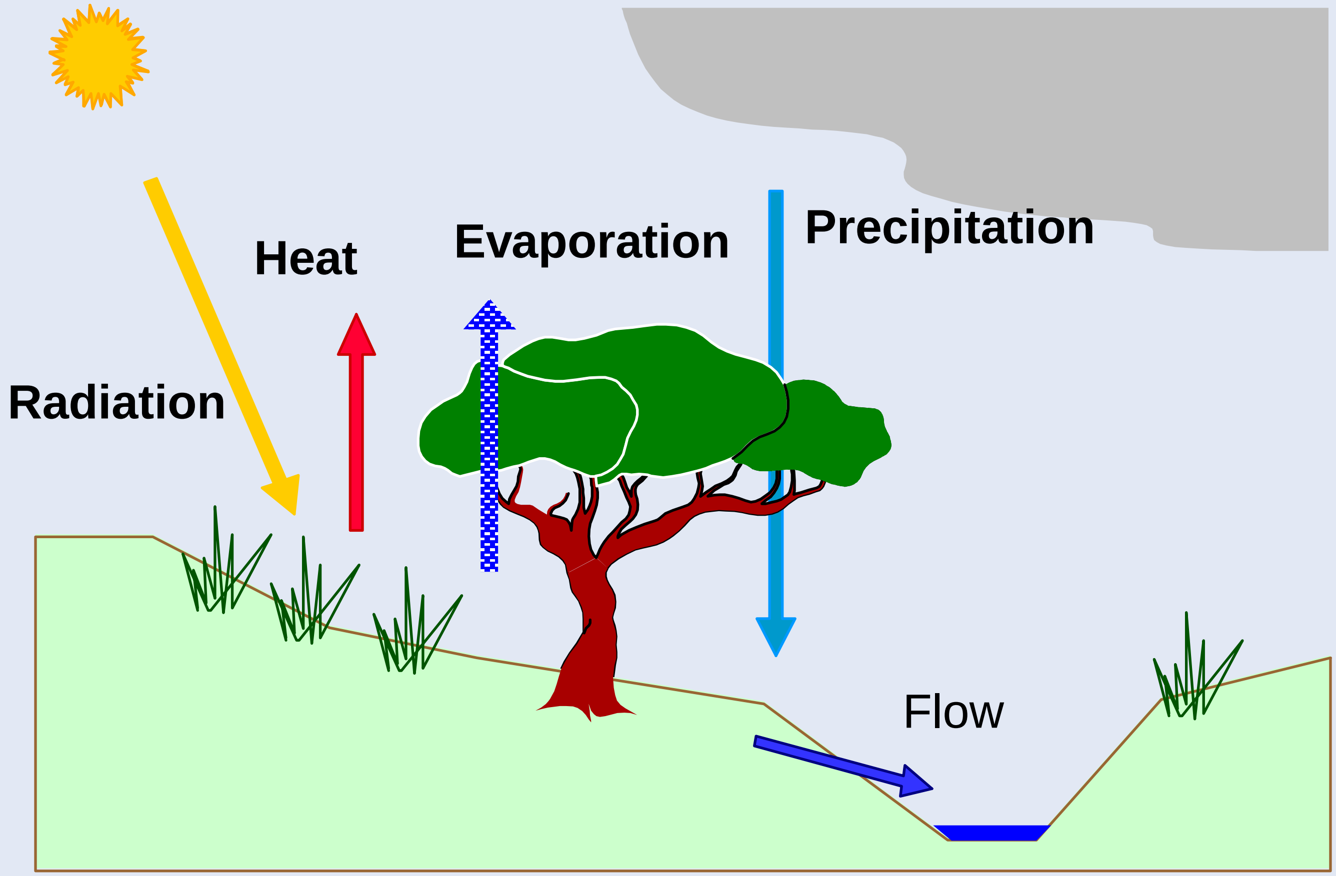
Meteosat






GOES W
(USA)
131°W
GMS
MTSat
140°E
FY2c
INSAT
(India)
94°E
GOES E
(USA)
98°W
35,900 km
0°
METEOSAT
(ESA)
METEOSAT IOC

Energy en Water Balance



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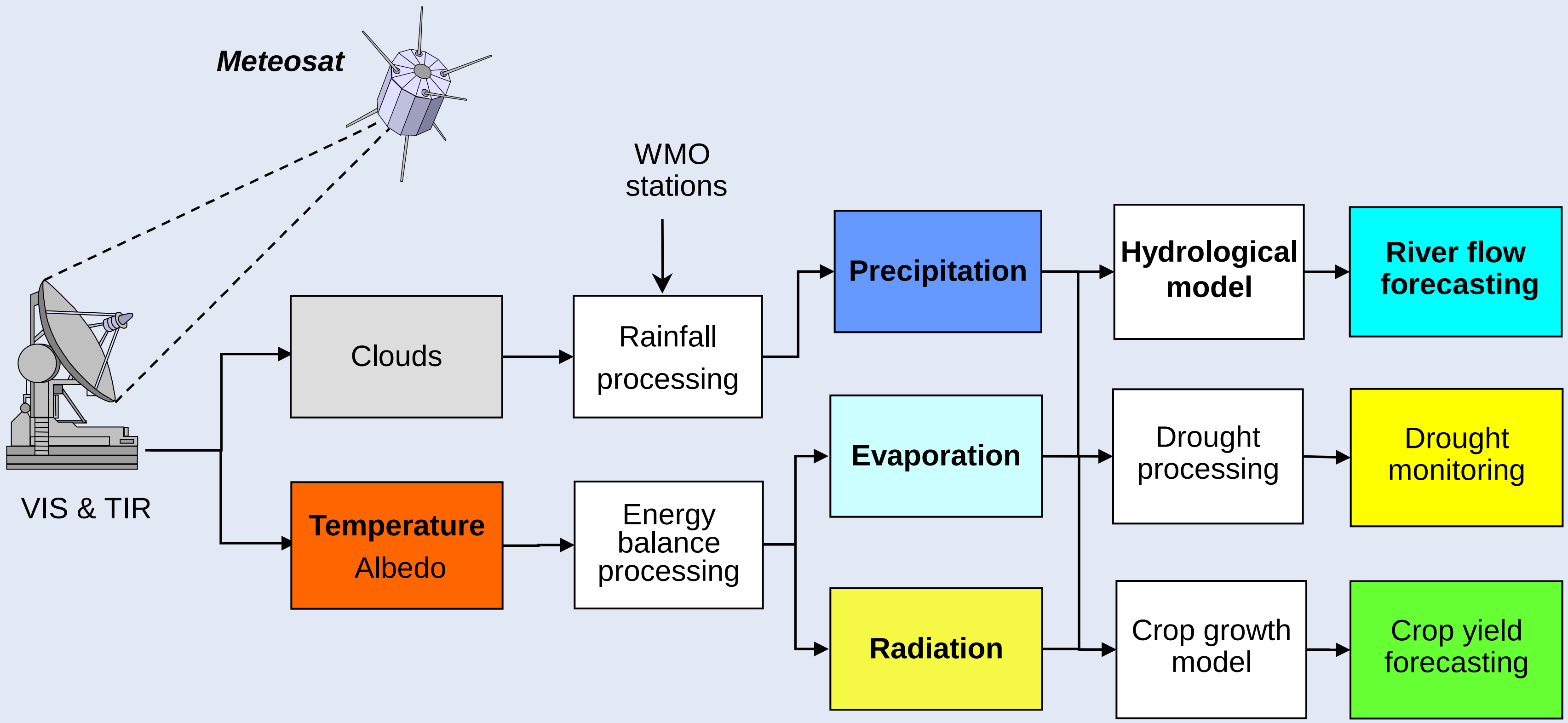
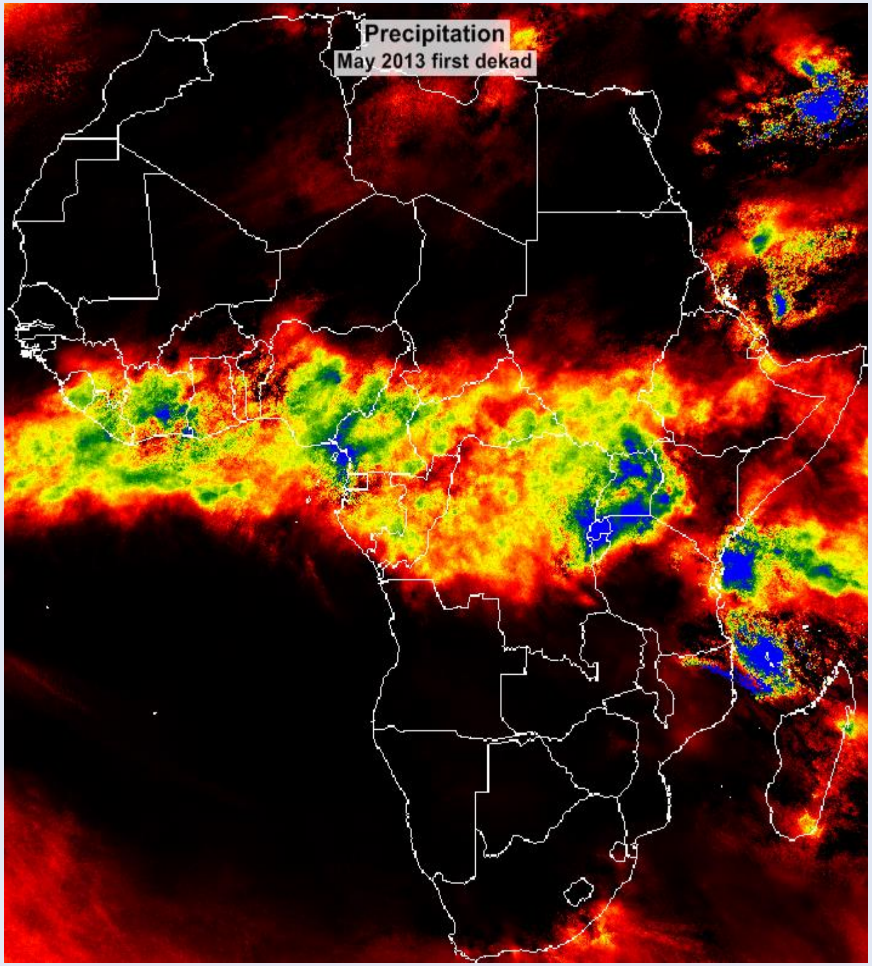
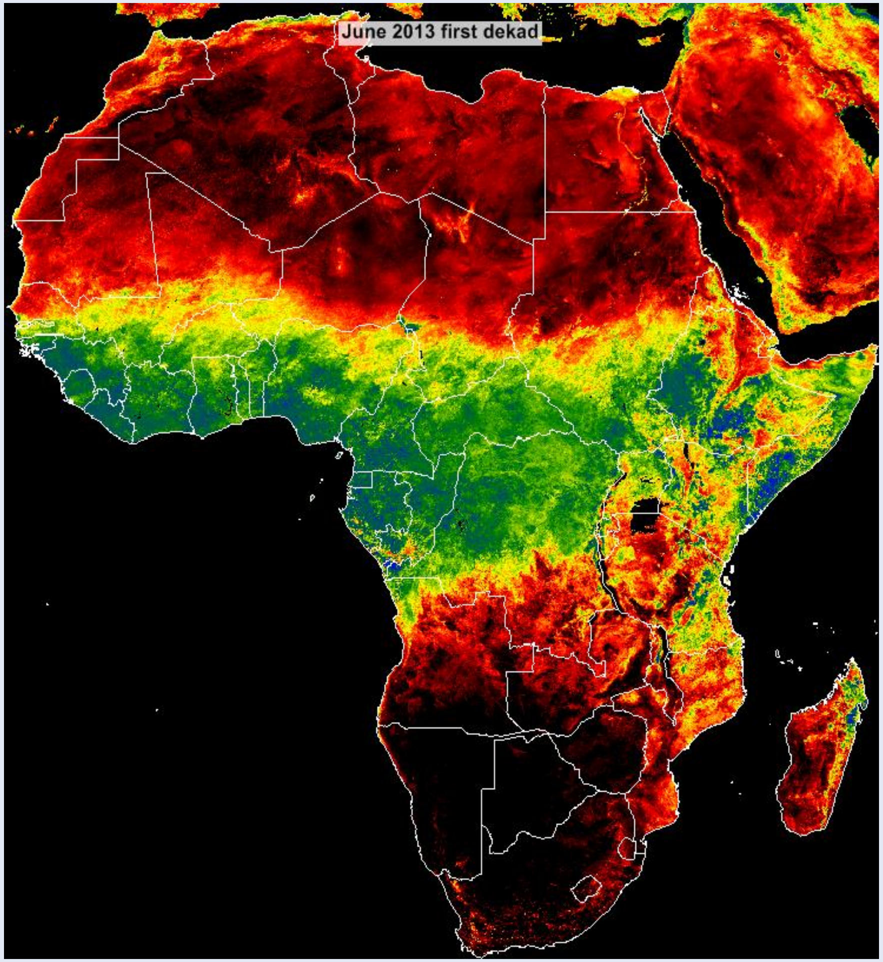
Energy and Water Balance Monitoring System (EWBMS)



Rainfall product



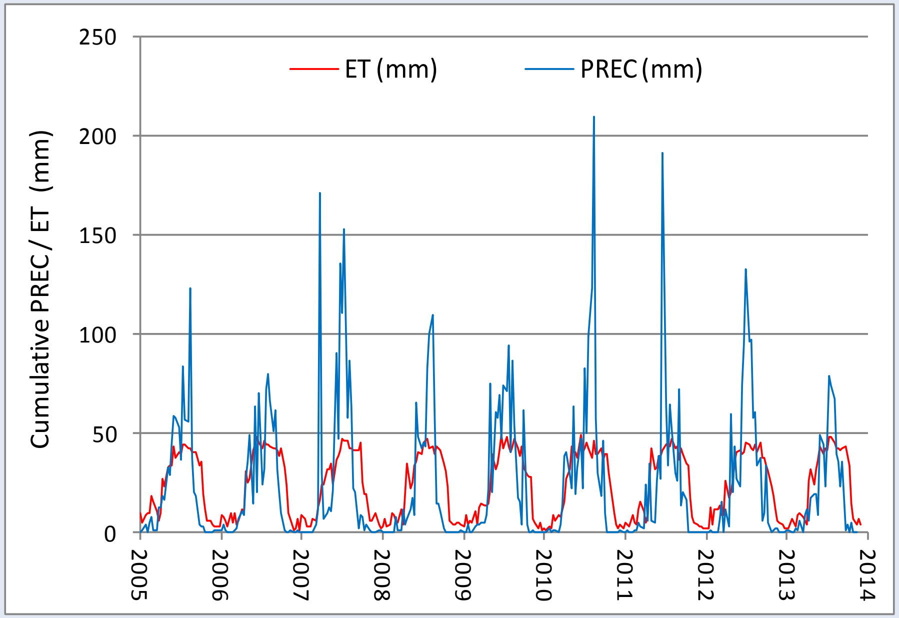
Actual evapotranspiration product



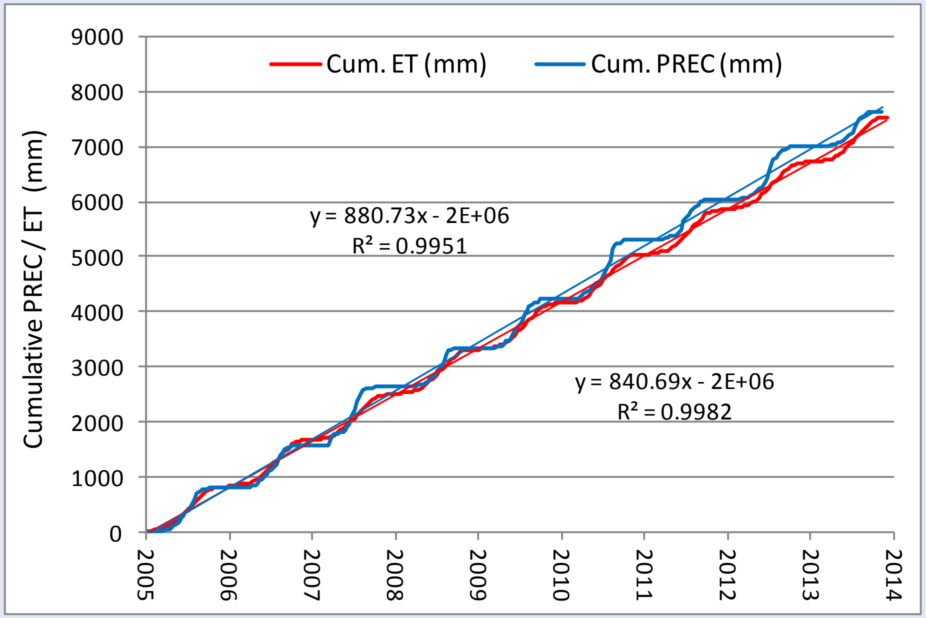
Water balance validation

- SW Burkina Faso reported run-off: 2-8% (Mahe et al. 2008)
- EWBMS using Meteosat: 4.5%

EWBMS rainfall & evapotranspiration



Same but cumulative



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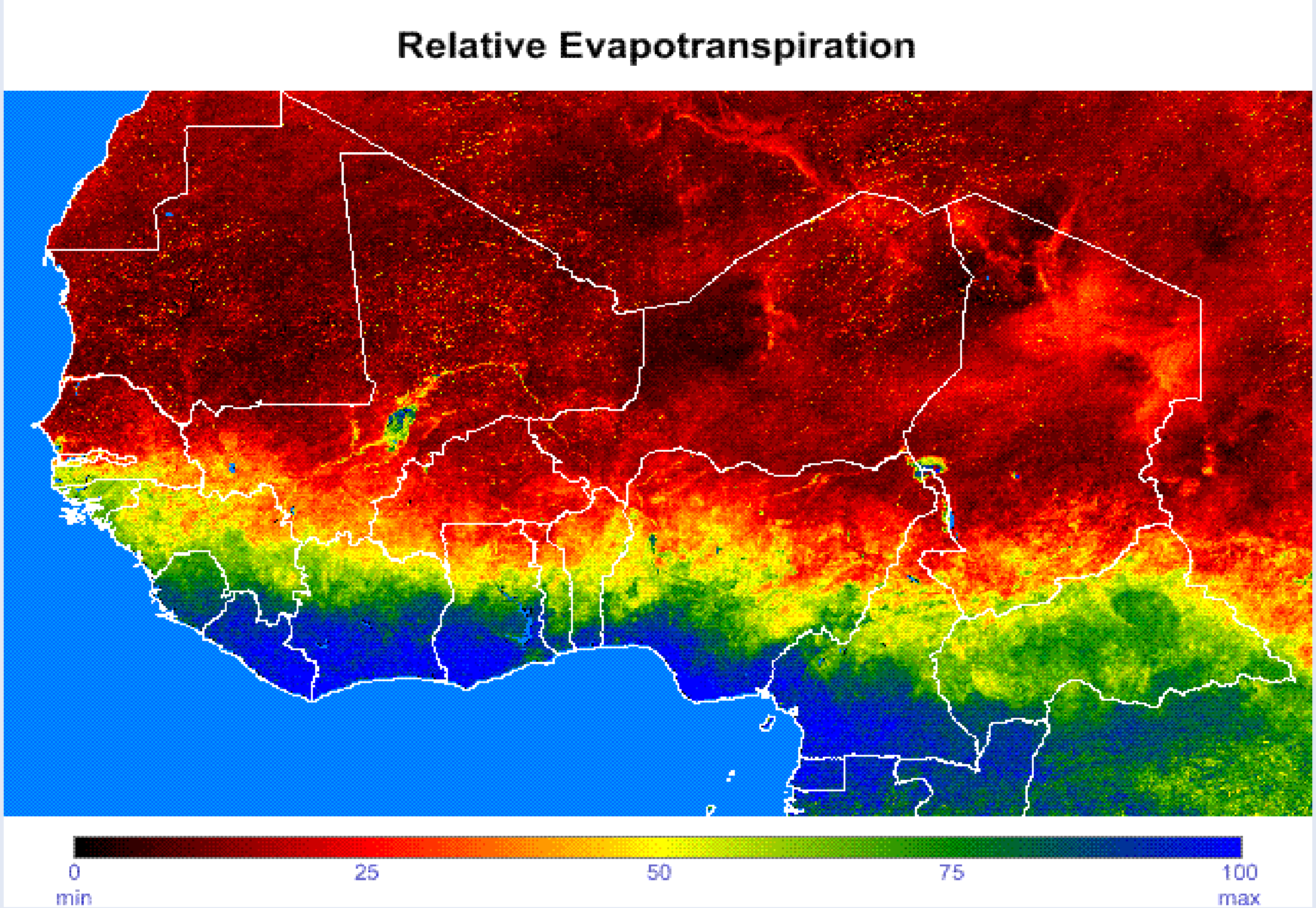
Time series (daily, 10-daily)



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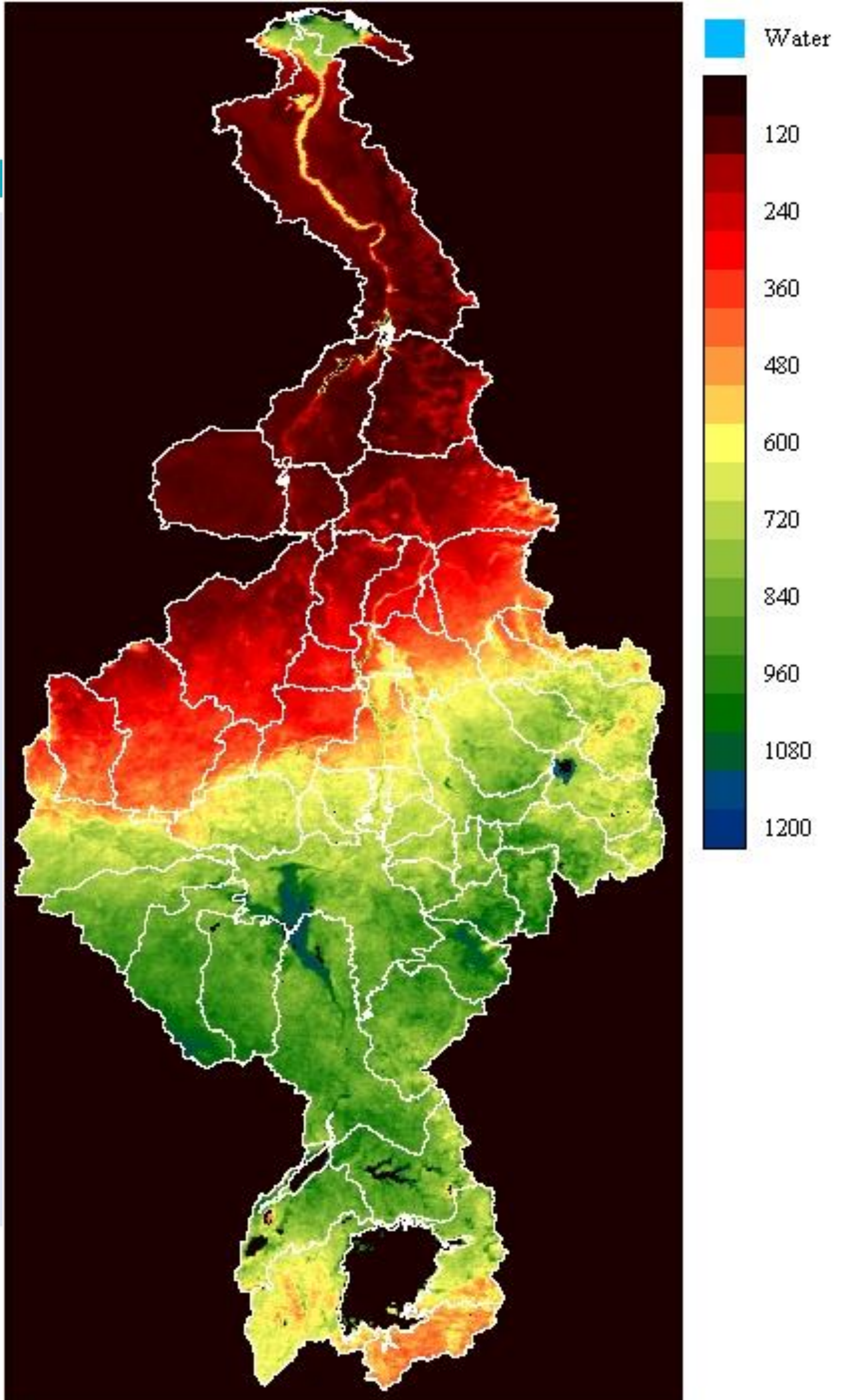
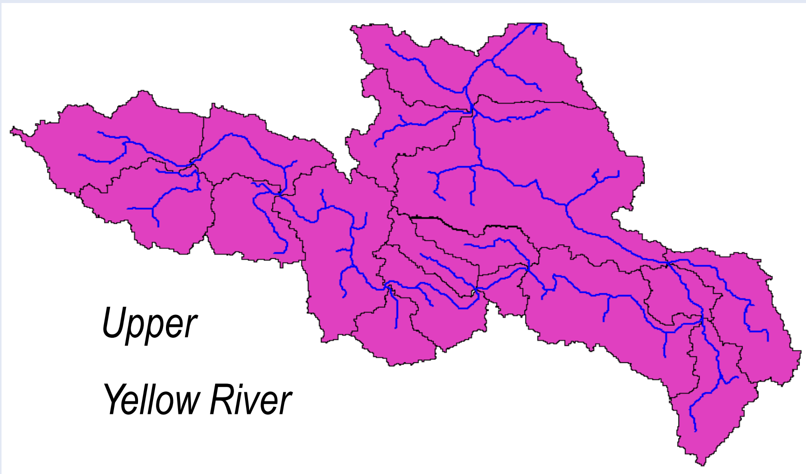
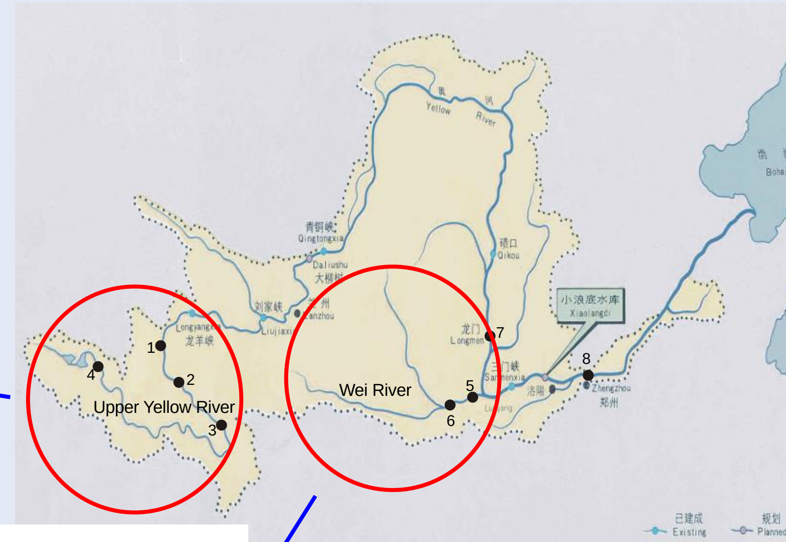
Complete river basins



Flow Forecasting

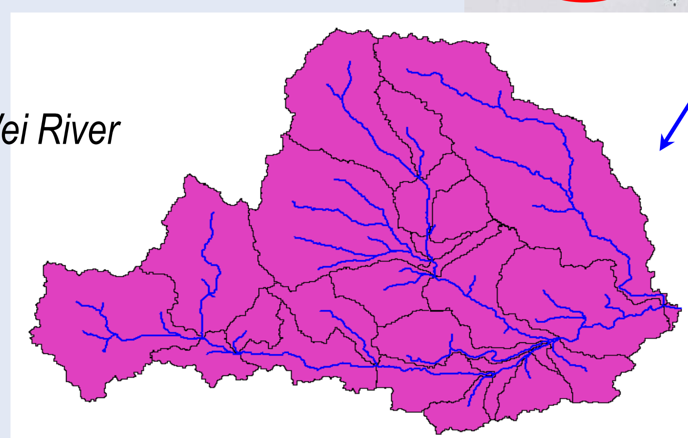
Yellow River basin project (2006-2009)





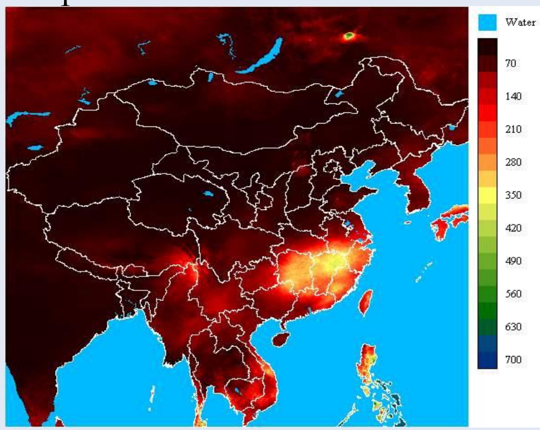
Second largest river basin of China

Wei River

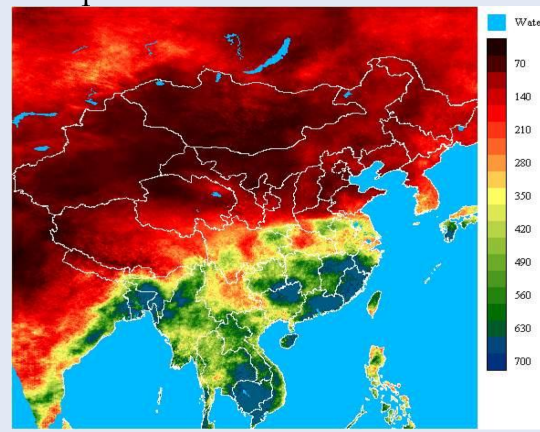


GMS / FY2 precipitation data

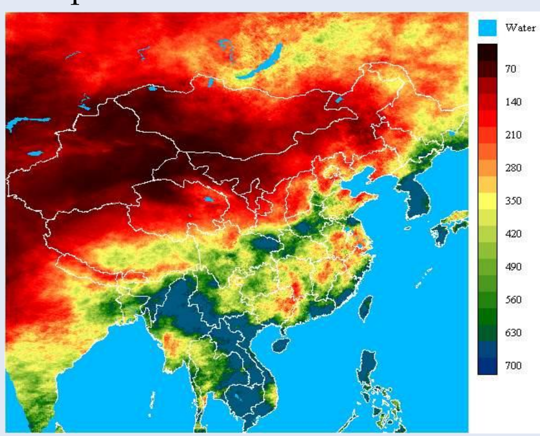
1st quarter 2000



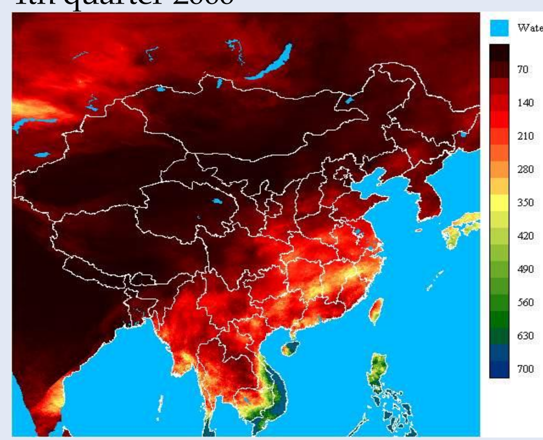
2nd quarter 2000



3rd quarter 2000

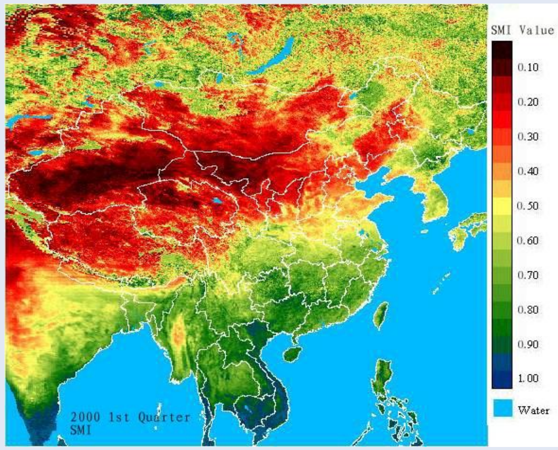


4th quarter 2000

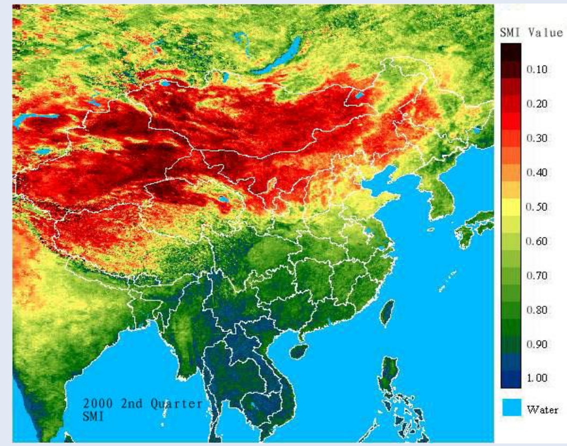


GMS / FY2 evapotranspiration data

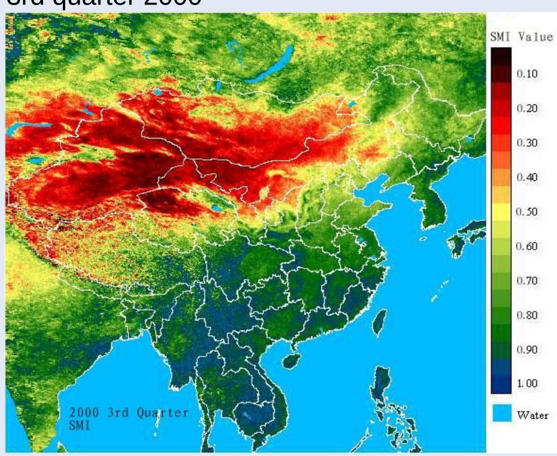
1st quarter 2000



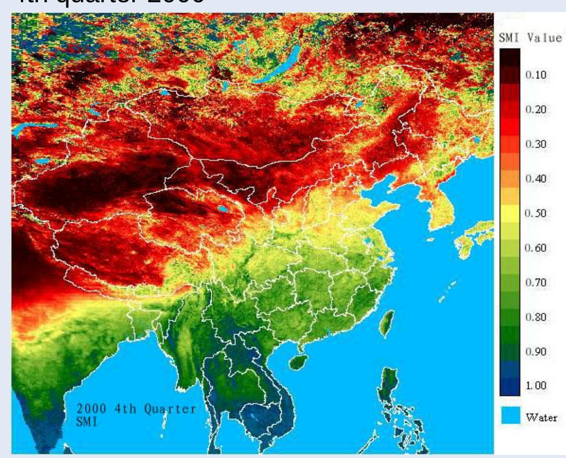
2nd quarter 2000



3rd quarter 2000

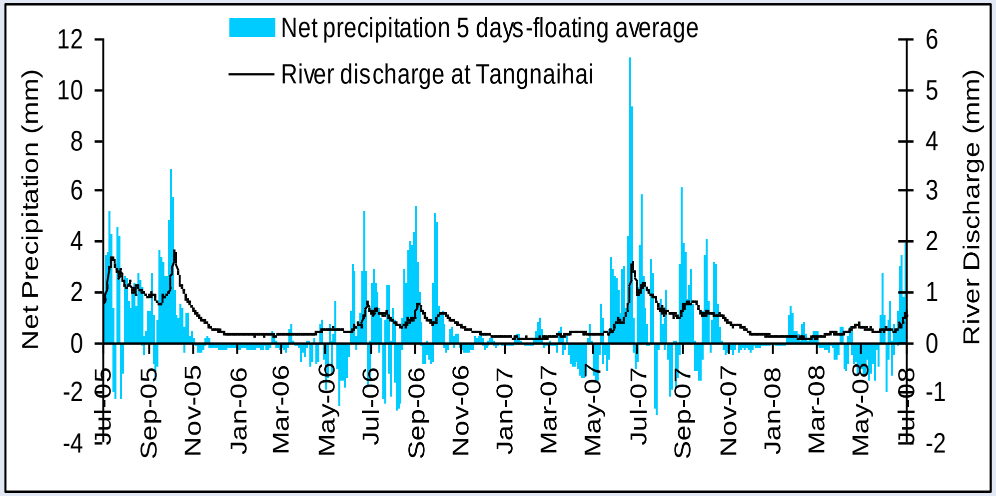


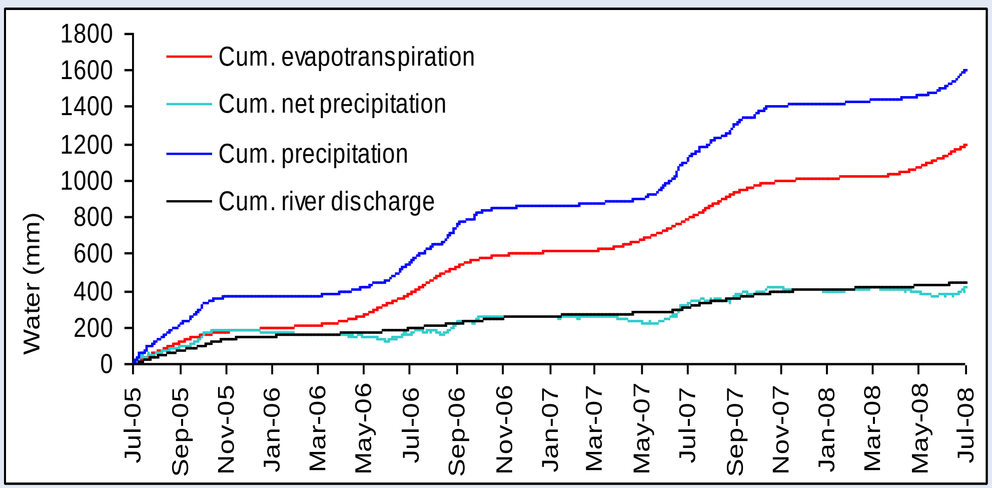
4th quarter 2000



Water balance validation

Upper Yellow River

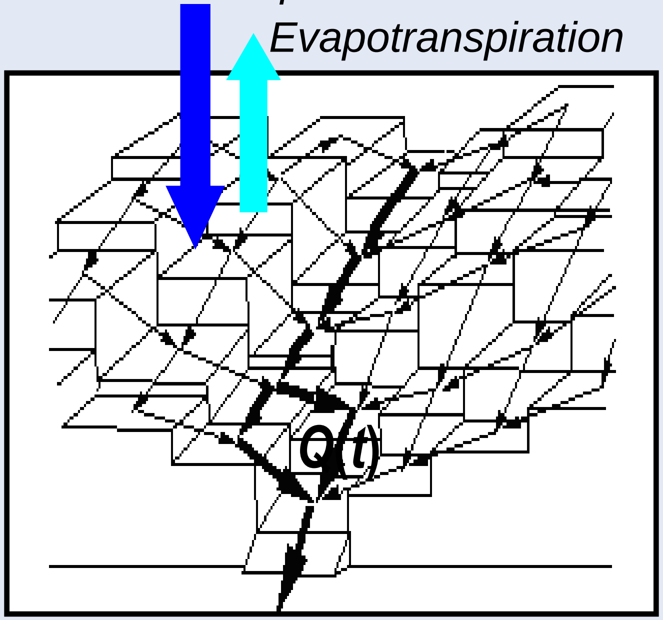




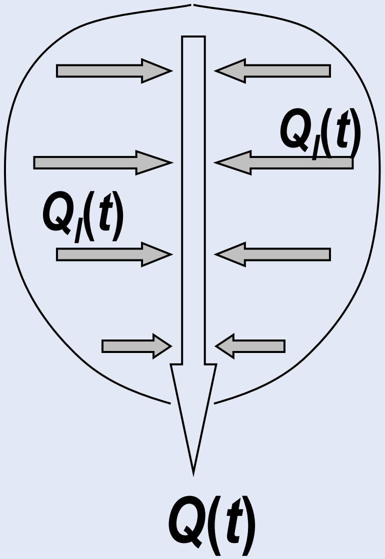
Large Scale Hydrological Model (LSHM)

Land component:
2-dimensional diffusion process
Surface & sub-surface flow

EWBMS Precipitation &
Evapotranspiration



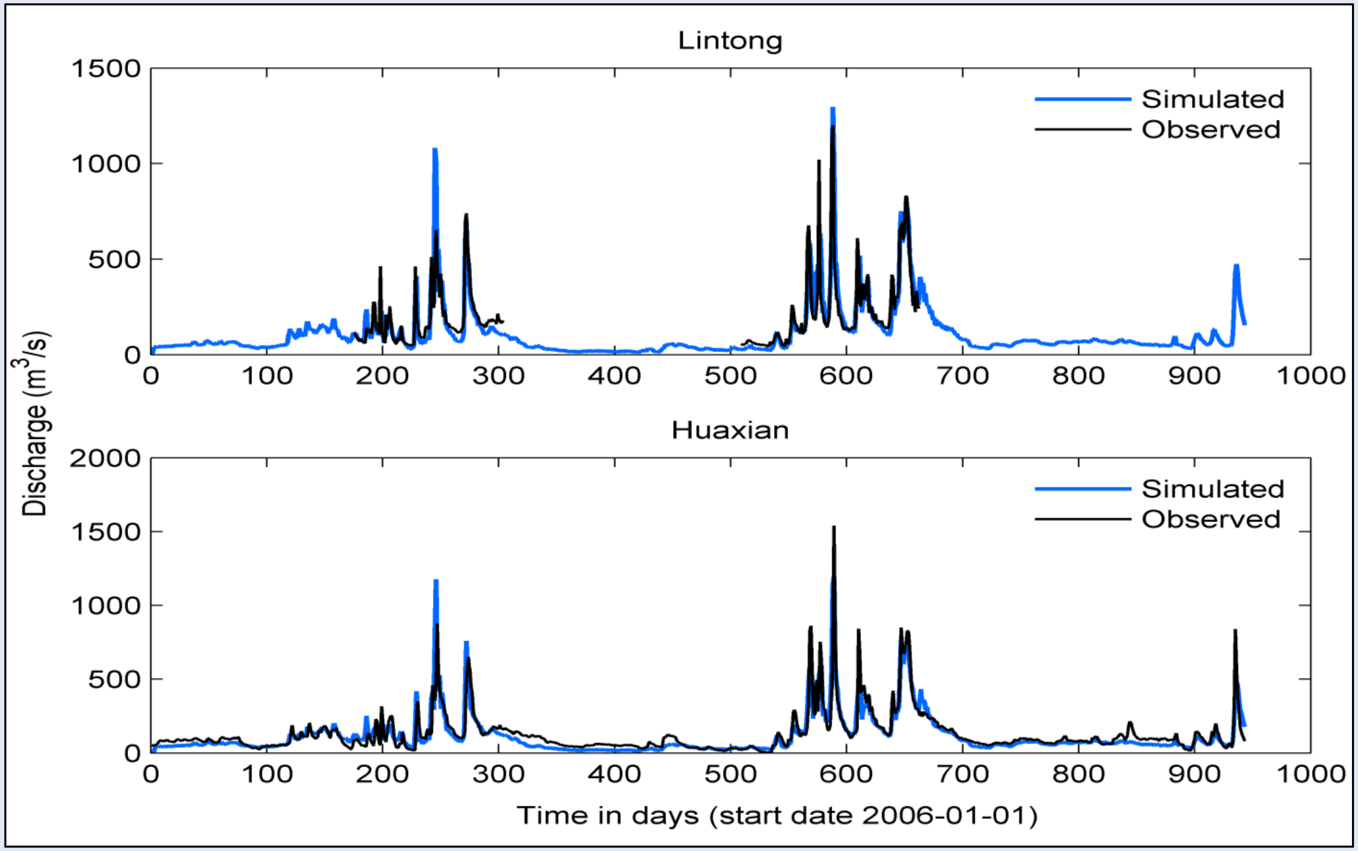
River flow component:
Muskingum-Cunge routing



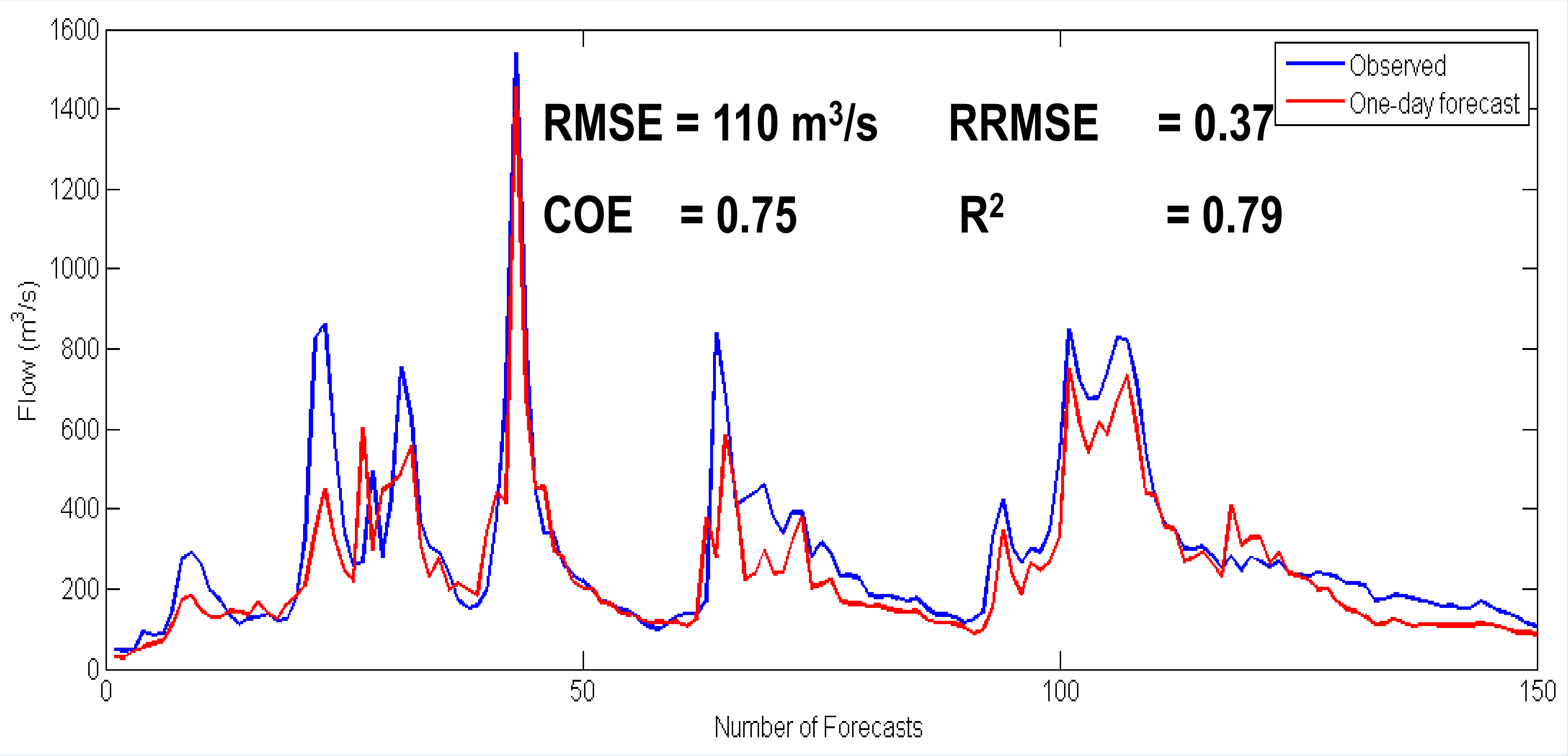
Wei River flow simulation

$R^2 = 0.75$
Vol. error = 4%

$R^2 = 0.80$
Vol. error = 11%



Wei River 24 hr forecast



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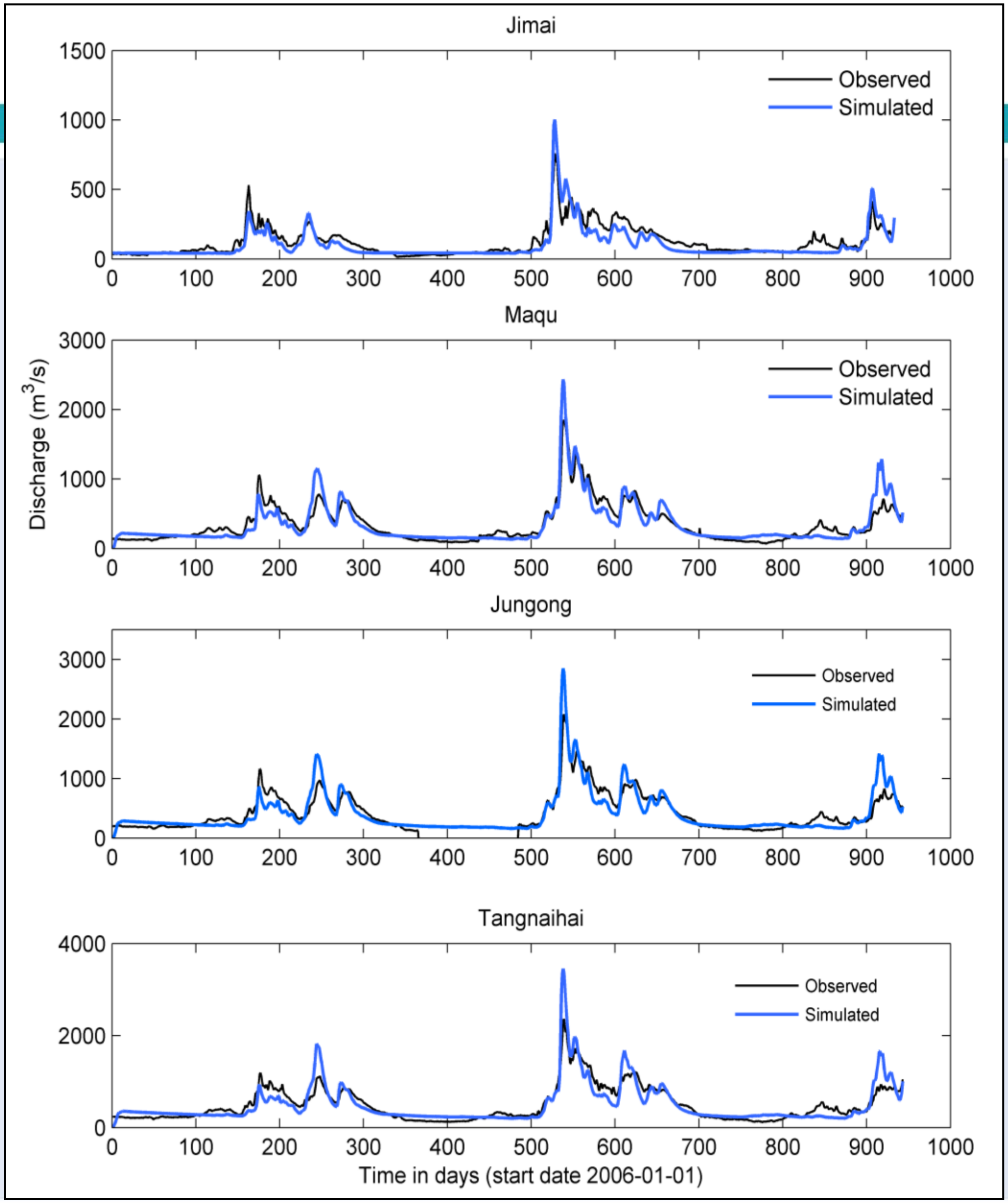
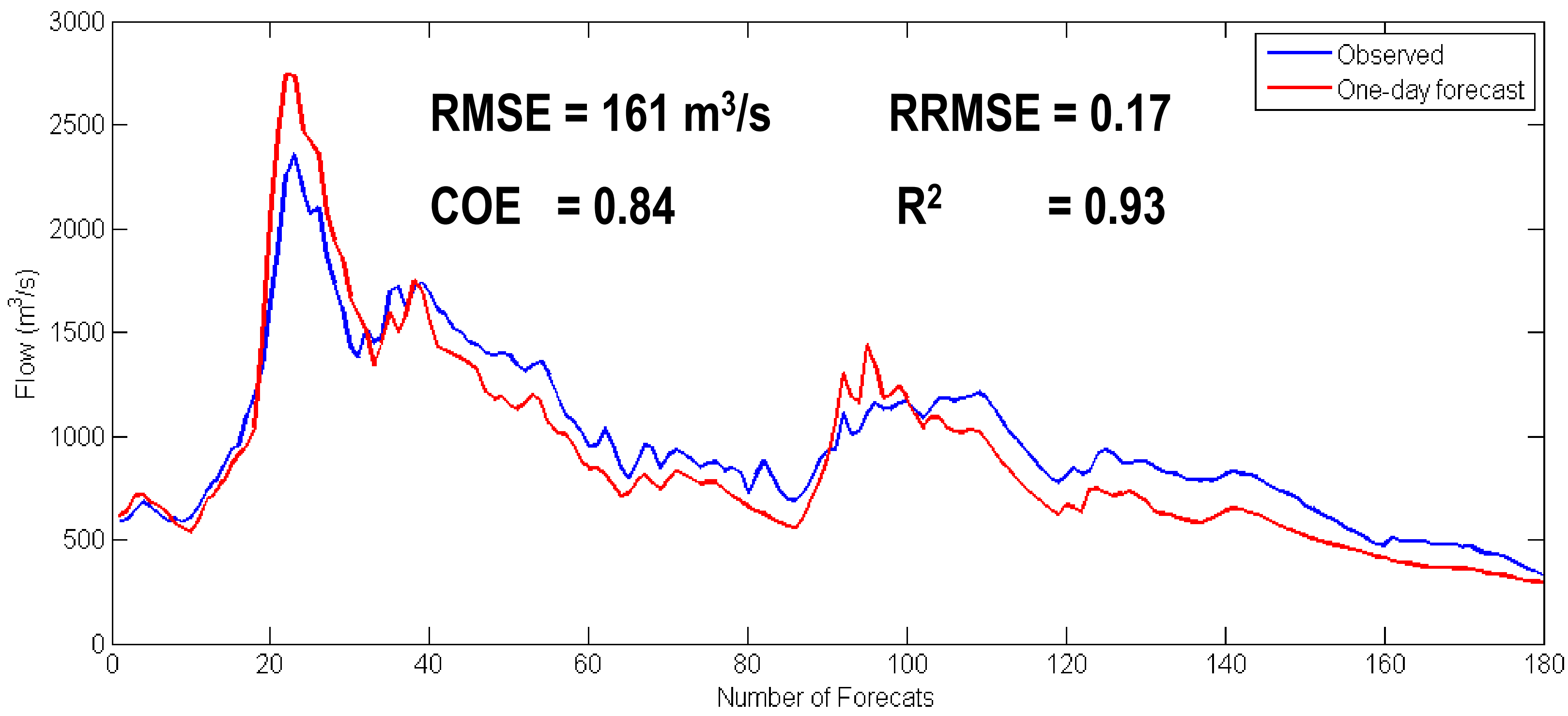
Upper Yellow River flow simulation



Station	R^2	*Volume difference*
Jimai	0.80	+17.9 %
Maqu	0.82	- 0.61%
Jungong	0.80	+ 0.61%
Tangnaihai	0.80	- 0.67%

Upper Yellow River 24 hr forecast



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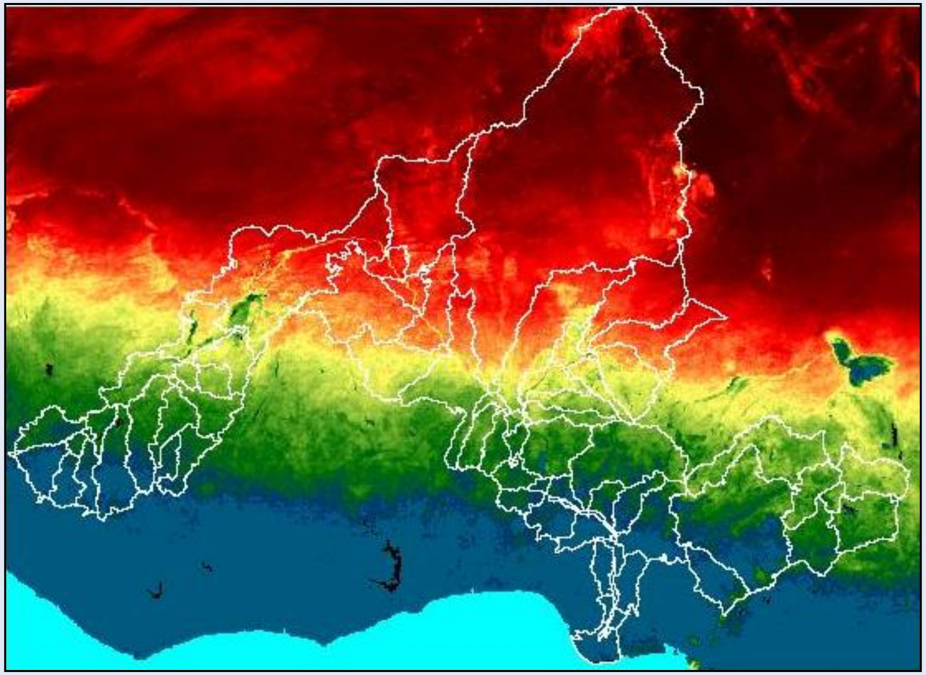
High level interest at the
2nd International Yellow River Forum
Zhengzhou, October 2005

Yellow River project evaluation

- By a Chinese high-level scientific commission
- Classification: “World Leading Level”
- 2nd Prize China Ministry of Water Resources

Niger Basin project (2014-2017)

- Niger Basin Authority, Niamey, Niger
- Operational implementation
- Drought monitoring
- River flow forecasting



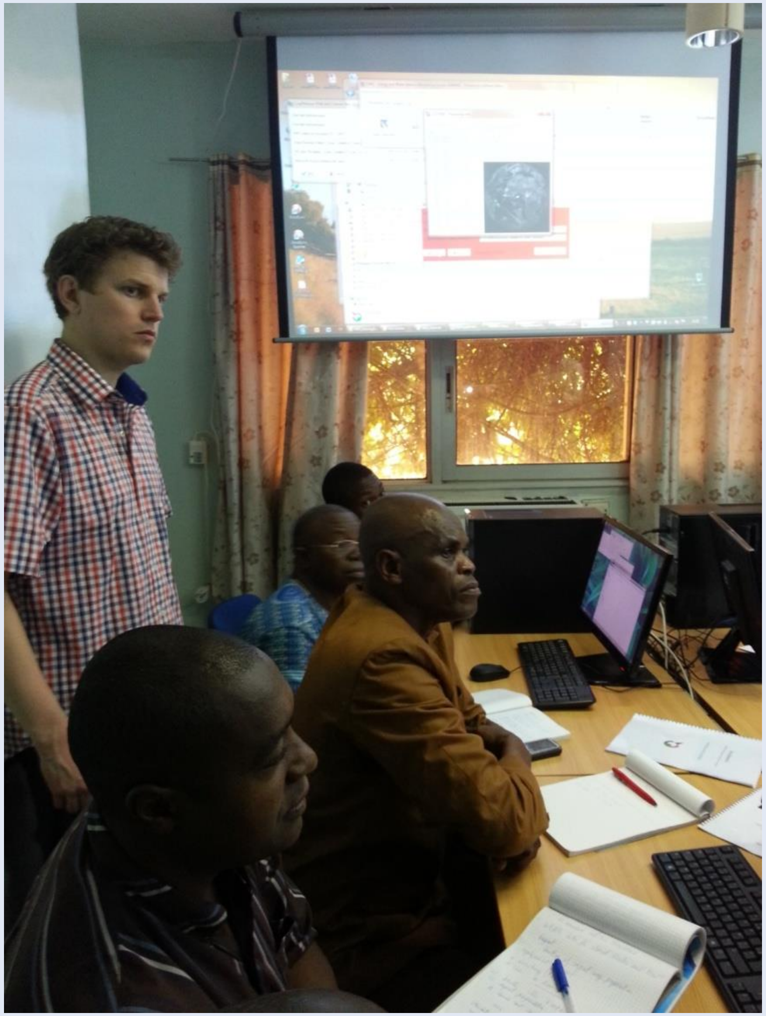
Project components

- Meteosat receiver
- PC network
- Software
  - Pre-processing
  - EWBMS
  - LSHM
  - Utility GIS
- Validation
- Calibration
- Training

Meteosat antenna

Receiving and processing office

Training



Drought monitoring

EWBMS drought information

- Meteorological drought — SPI
- Hydrological drought — $EP = P – E_a$
- Agricultural drought — $RE = LE_a / LE_p$
- Climatic drought (> 1 yr)
  - Climatic Moisture Index (UNEP) — $CMI = P / LE_p$
  - Environmental Moisture Index — $EMI = LE_a / LE_p$

Evapotranspiration & crop growth

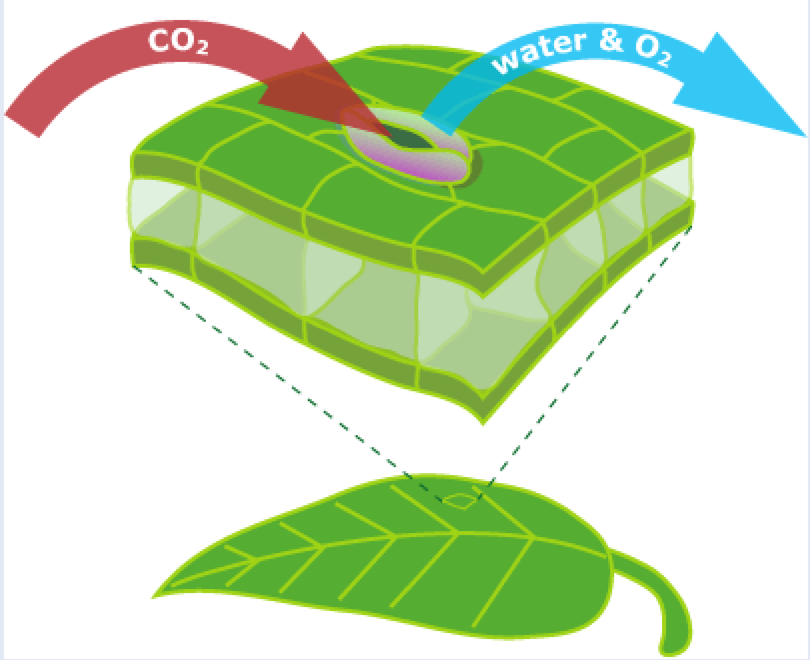
- Evapotranspiration ≈ transpiration
- CO_2 uptake proportional to crop growth

$$1\text{-}RY = k^*(1\text{-}RE)$$

Doorenbos & Kassam (1979)

"*Yield Response to Water*"

FAO Irrigation & Drainage Paper 33



Relative evapotranspiration (RE)

Agricultural drought ìndex used for:

- Irrigation scheduling / water allocation
- Crop yield forecasting
- Agricultural drought insurance

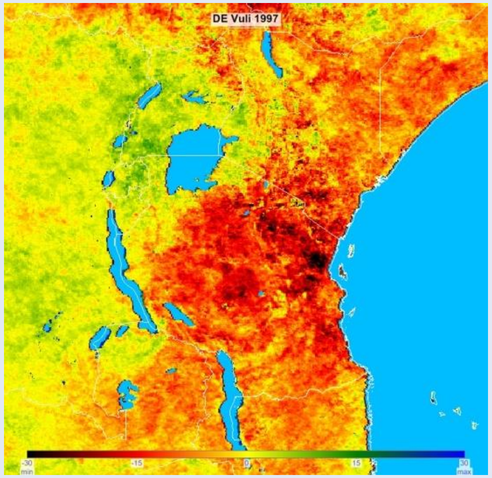
Difference evapotranspiration (DE)

$$DE = (RE - RE_{avg})/RE_{avg}$$

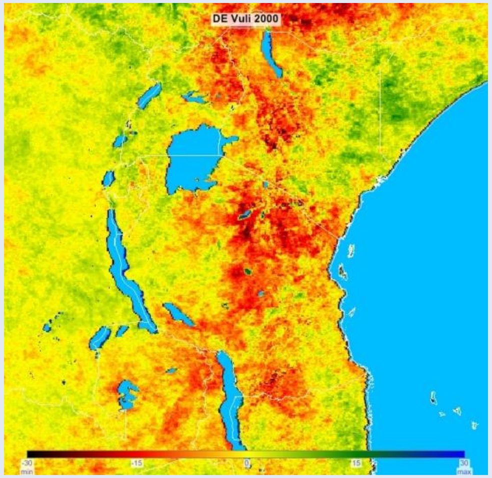
Drought monitoring East Africa

- DE East Africa
- Vuli season (Dec-Jan)
- Scale -30% to +30%
- Extreme drought in 2006

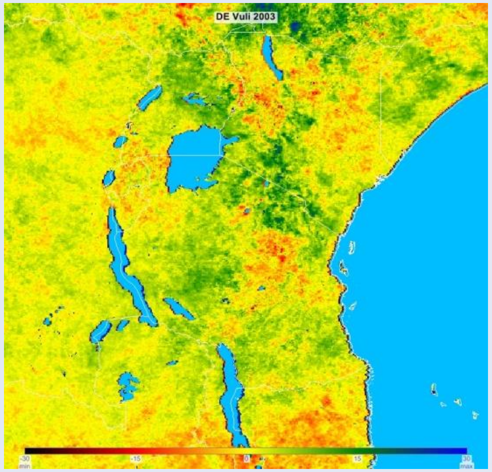
1997



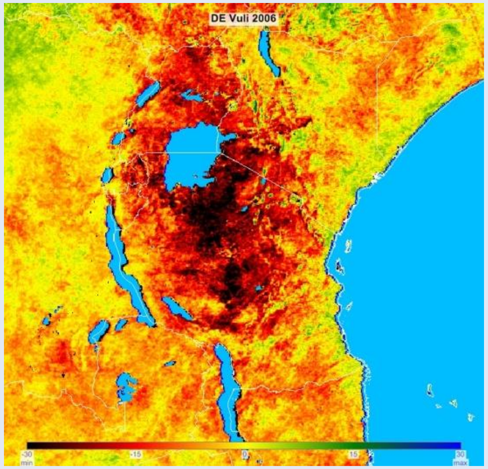
2000



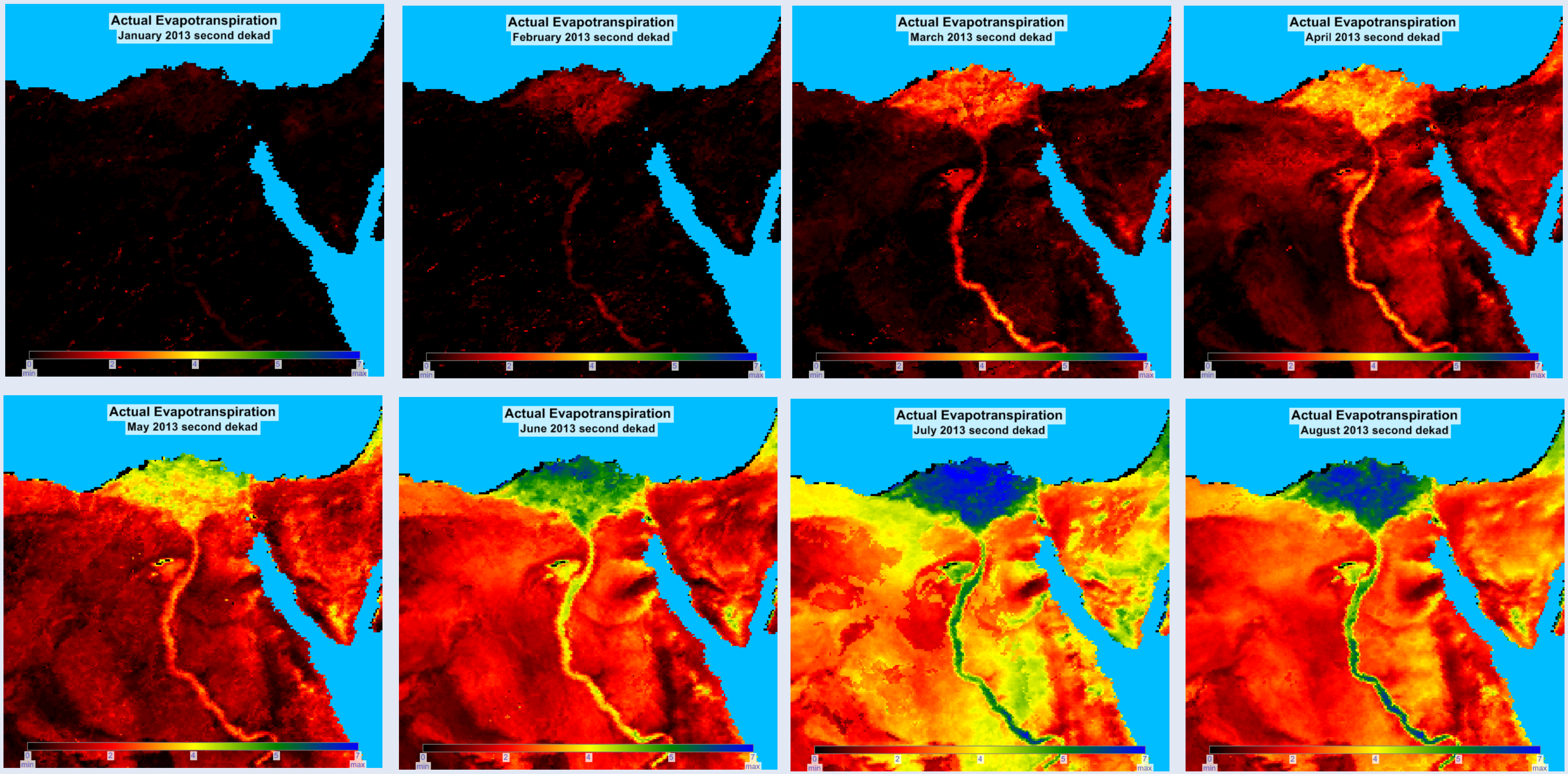
2003



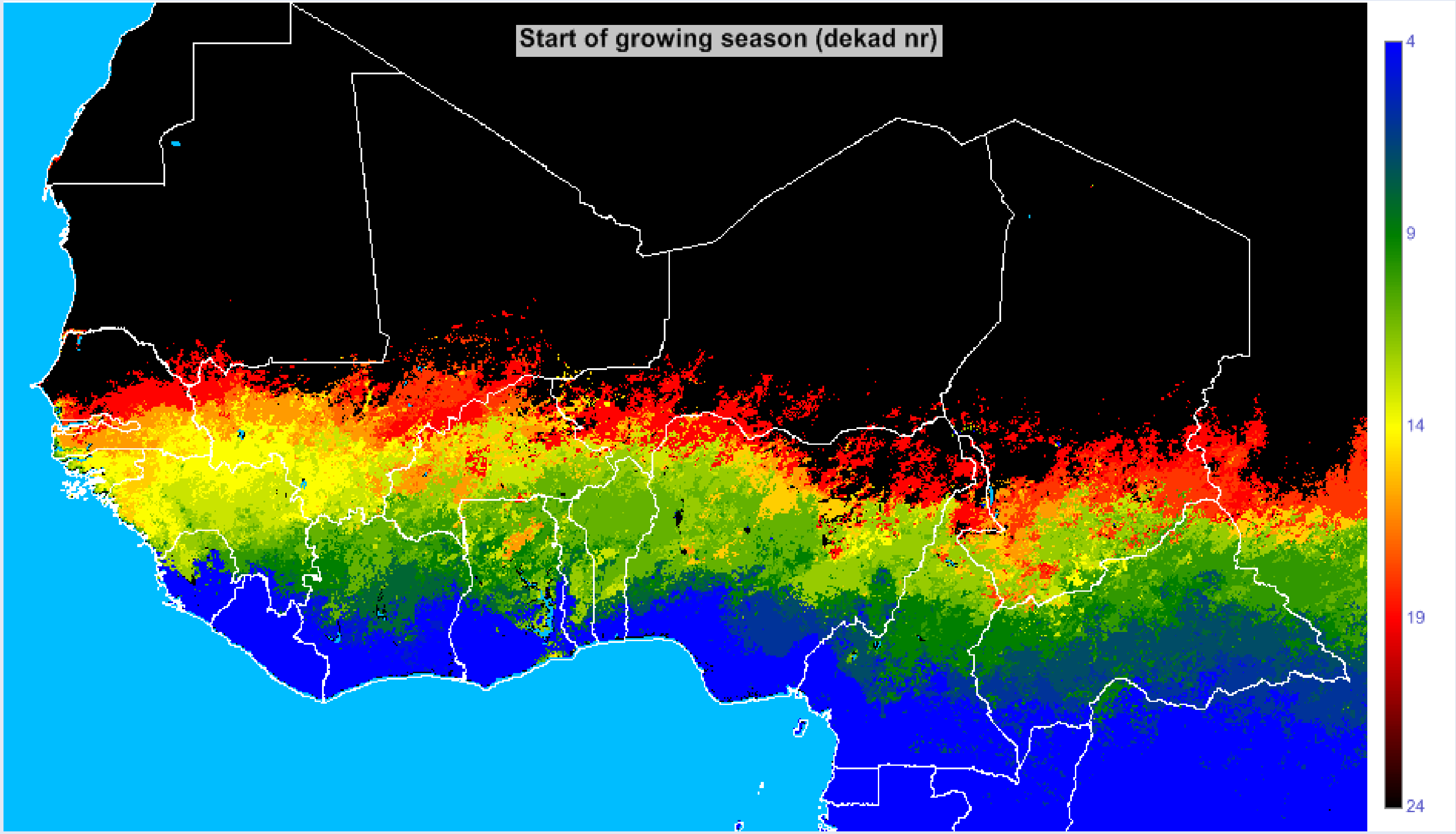
2006



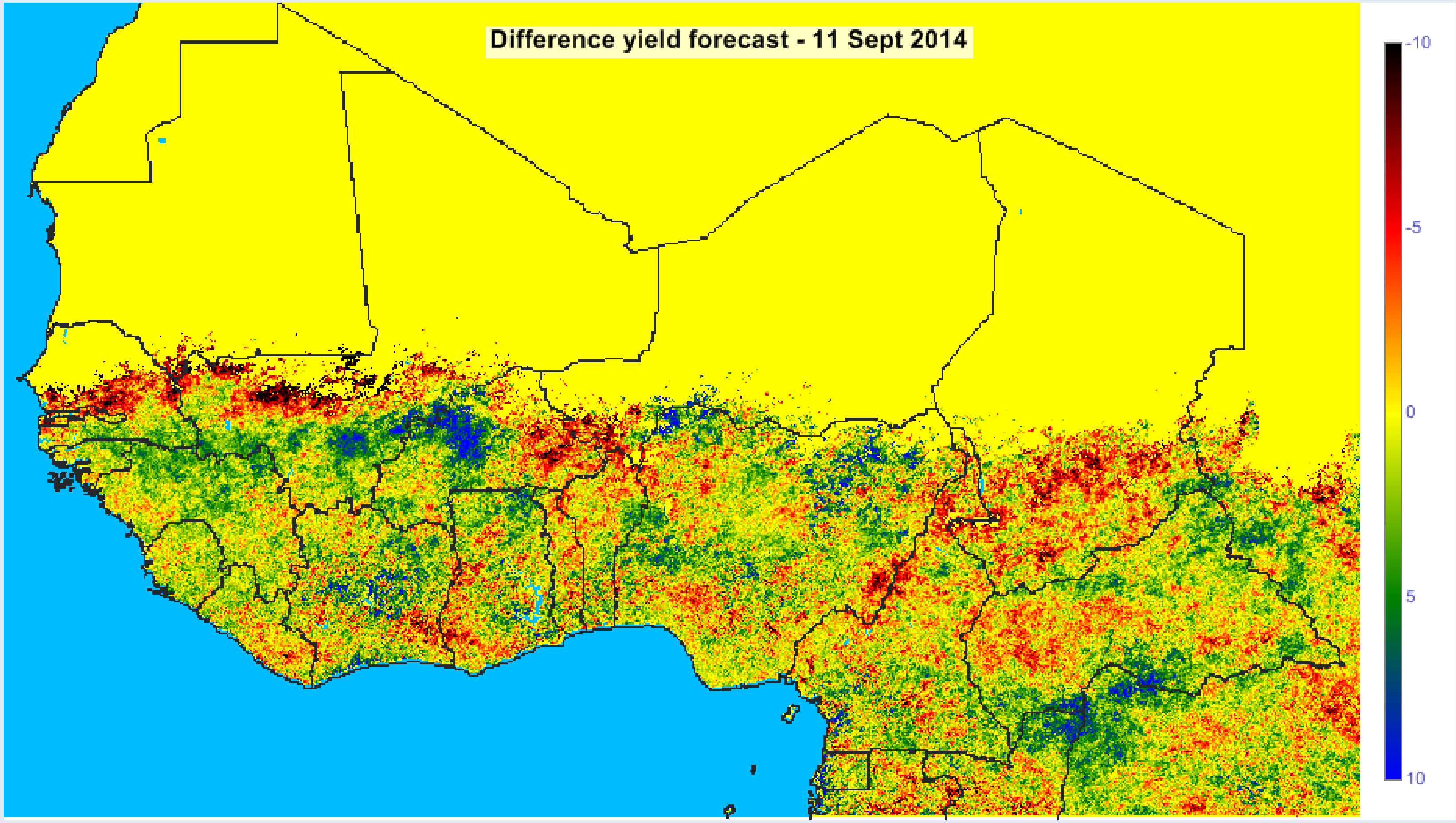
Irrigation patterns Niger delta



Start of 2014 growing season W-Africa



2014 Crop yield forecast



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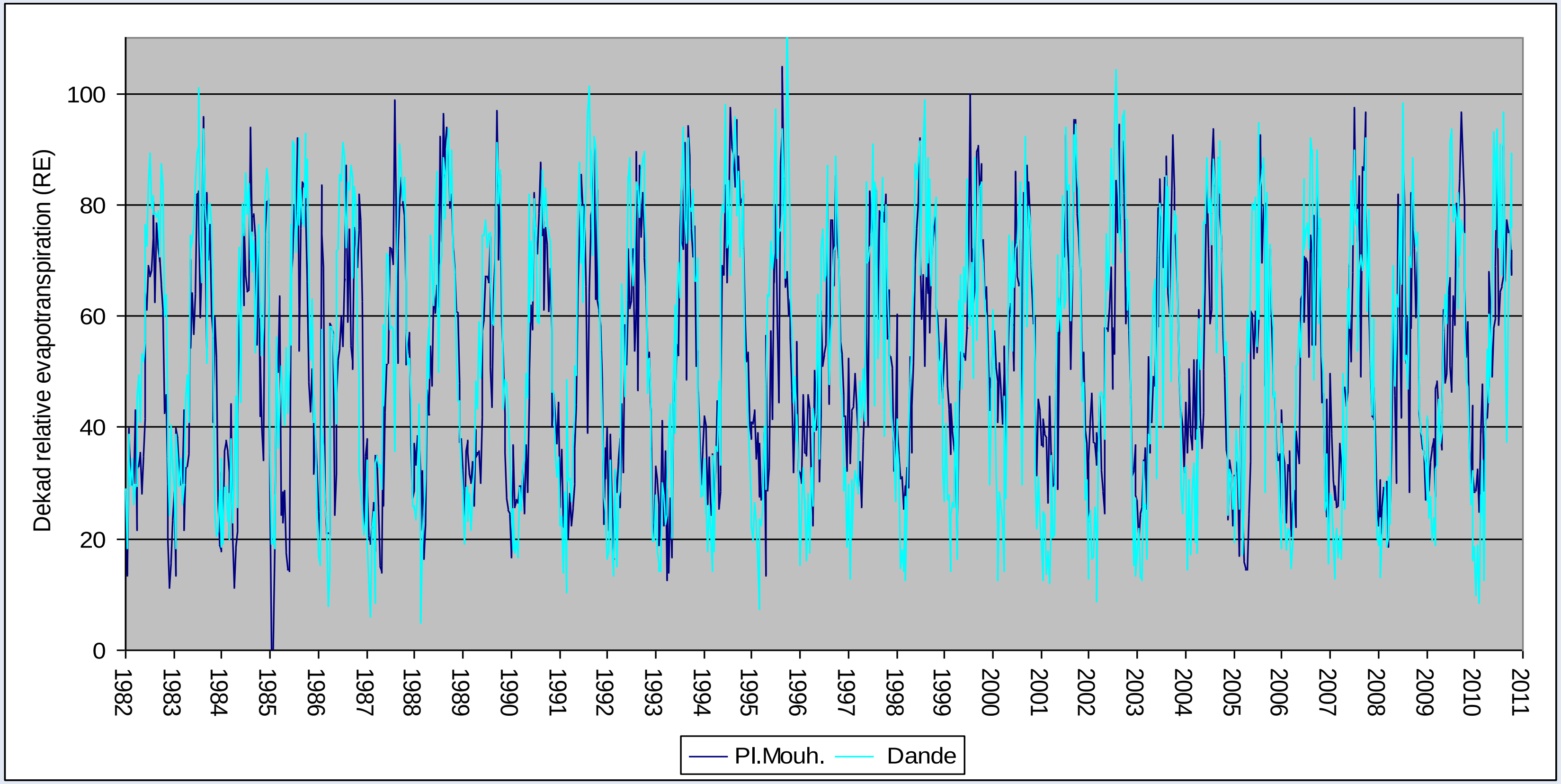
Long time series for index insurance design



- Location of growing season (starting window)
- Quality of growing season (RE)
- Historic risk assessment → insurance premium

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Index insurance

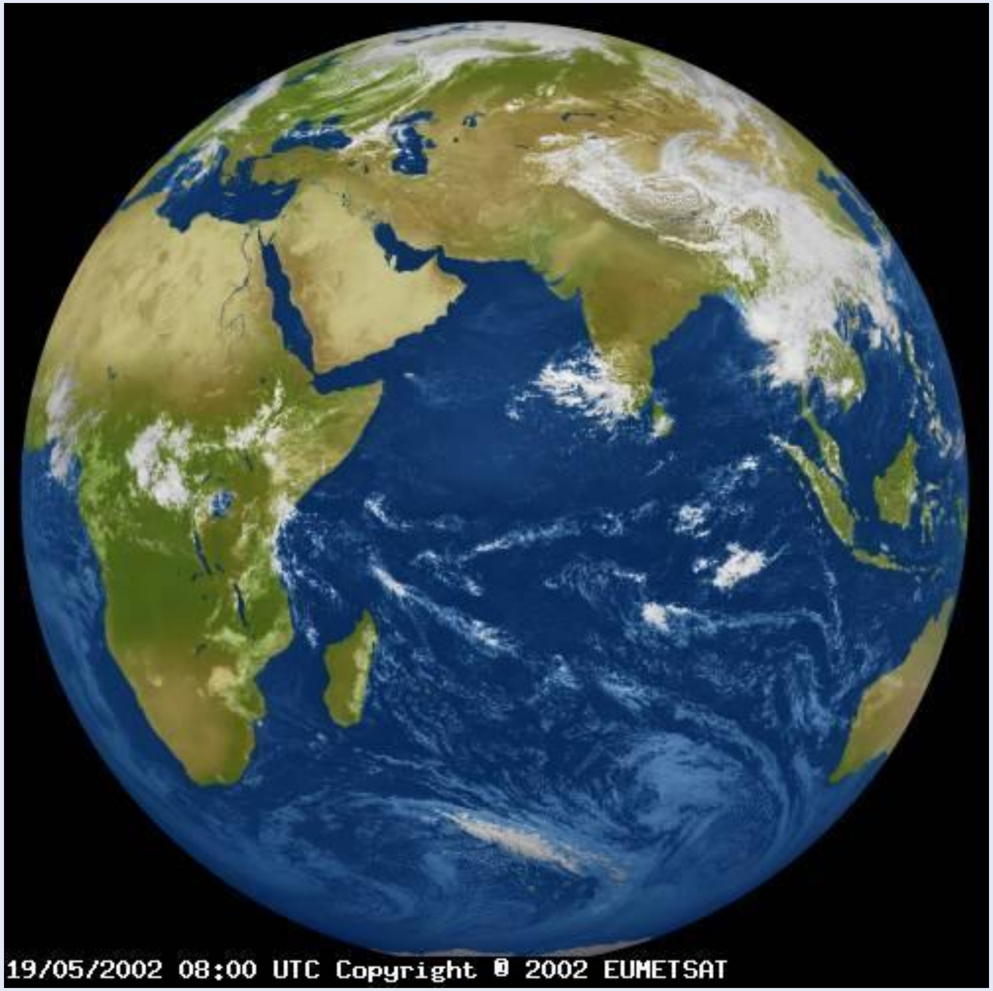
- Crops and livestock
- Drought and excessive precipitation
- In 10 African countries
- A dozen of insurance partners
- 23,000 farmers insured in 2013
- Target next 6 year: 1 million farmers

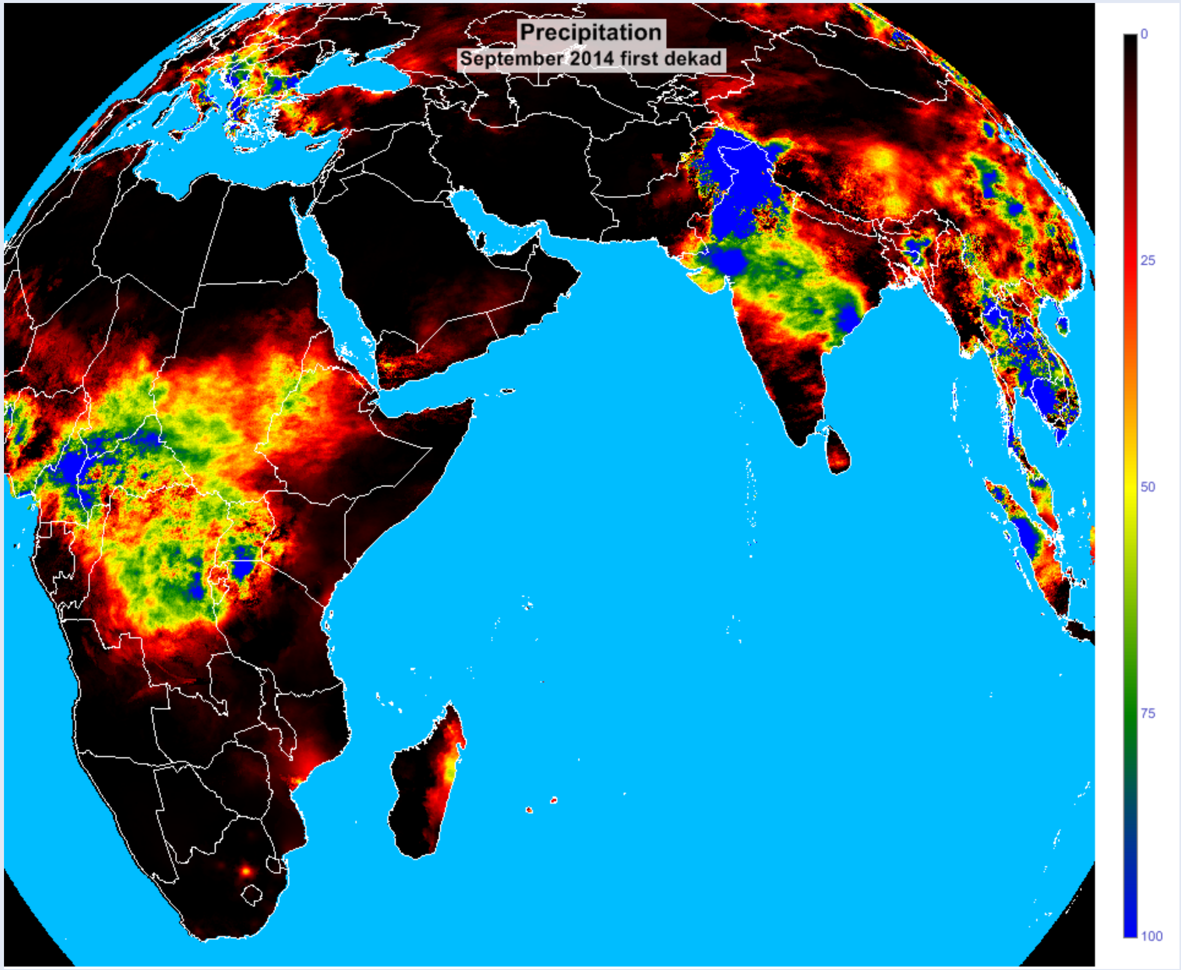
Conclusions

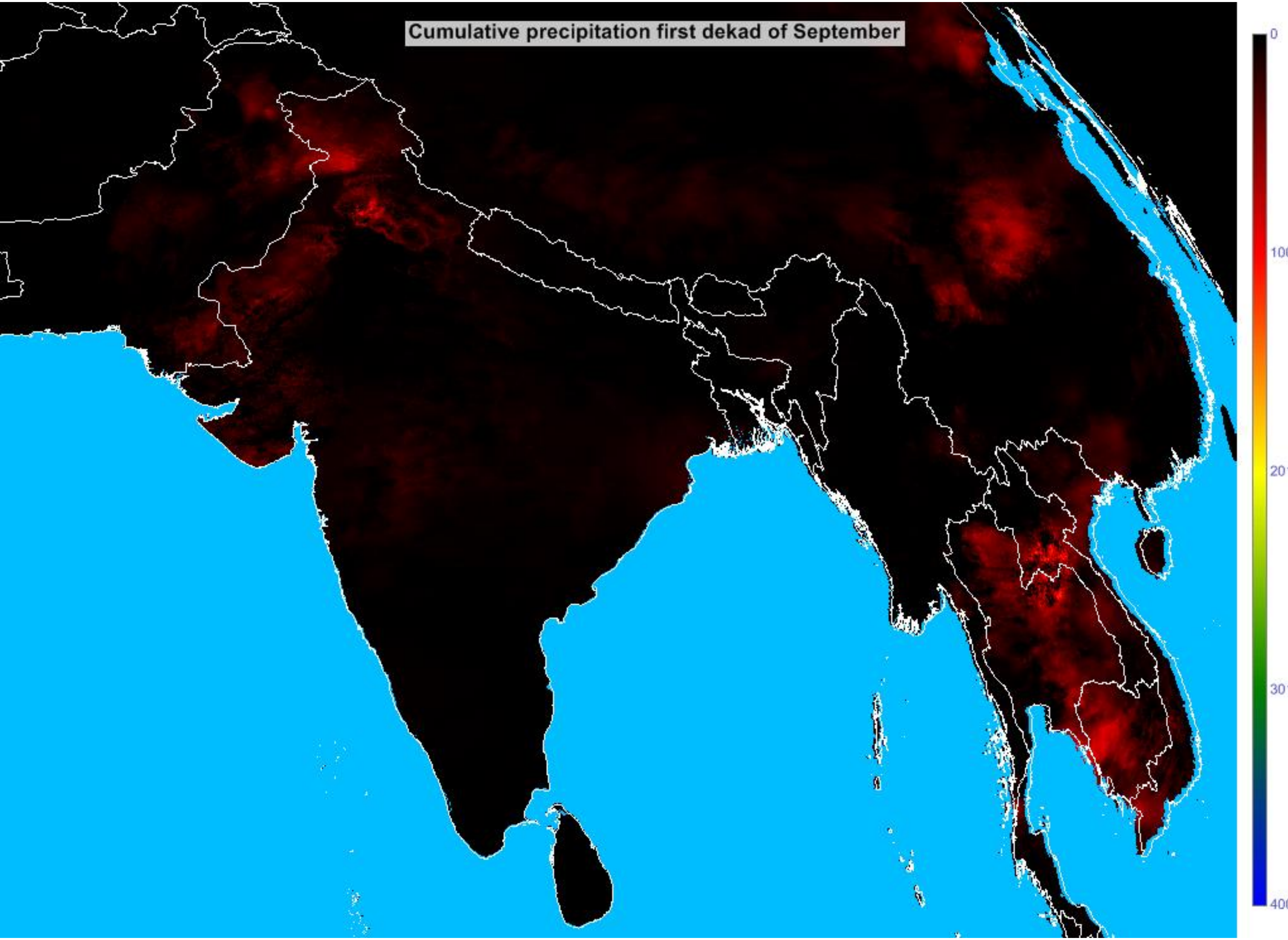
- Satellite based climate monitoring system
- Precipitation and evapotranspiration data
- Daily temporal resolution
- 3-5 km spatial resolution
- Distributed, transboundary
- Uniform
- Objective
- Validated
- Cost effective
- River flow forecasting
- Drought monitoring and water allocation
- Crop yield forecasting and crop insurance

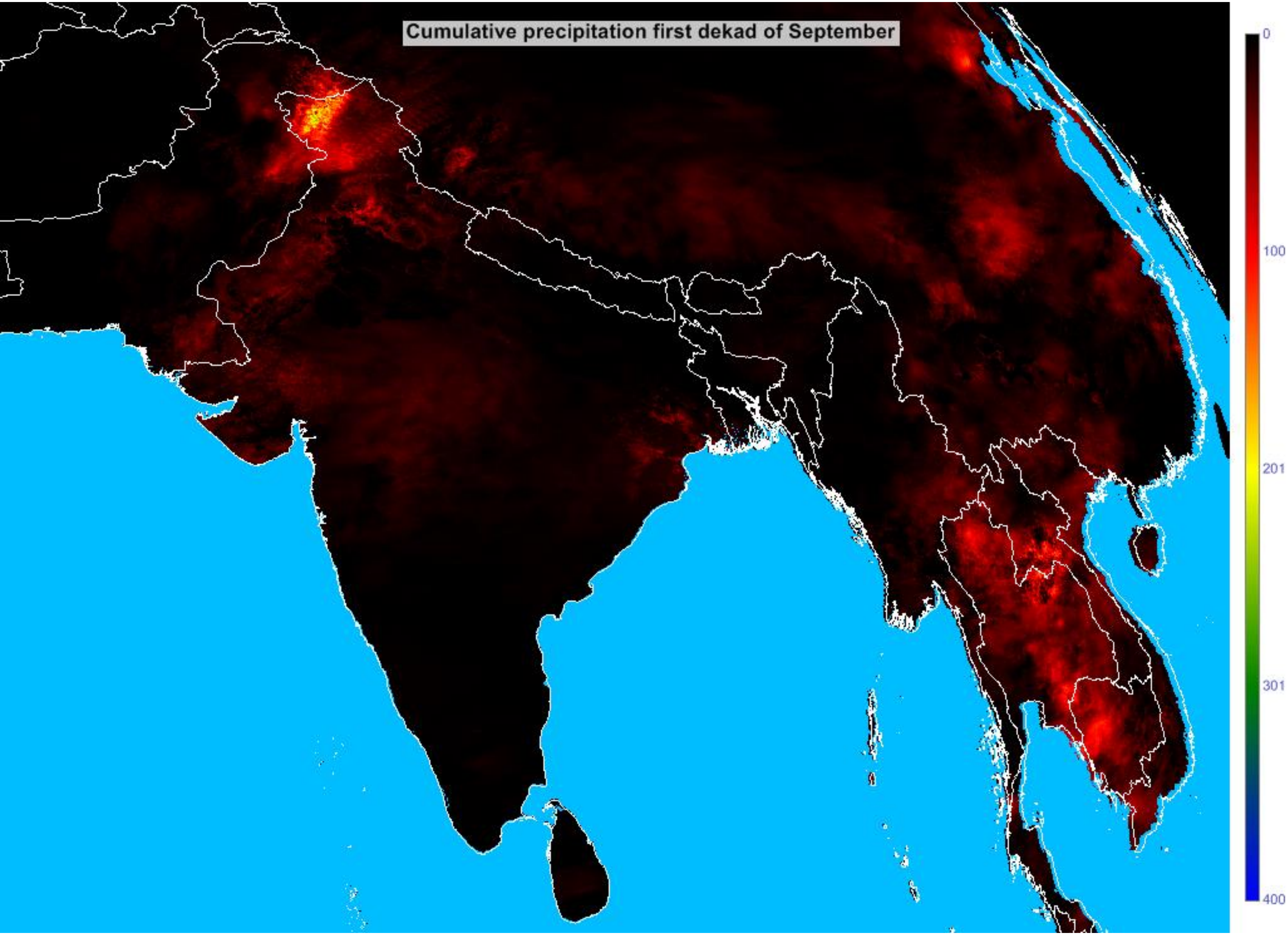
What about India?

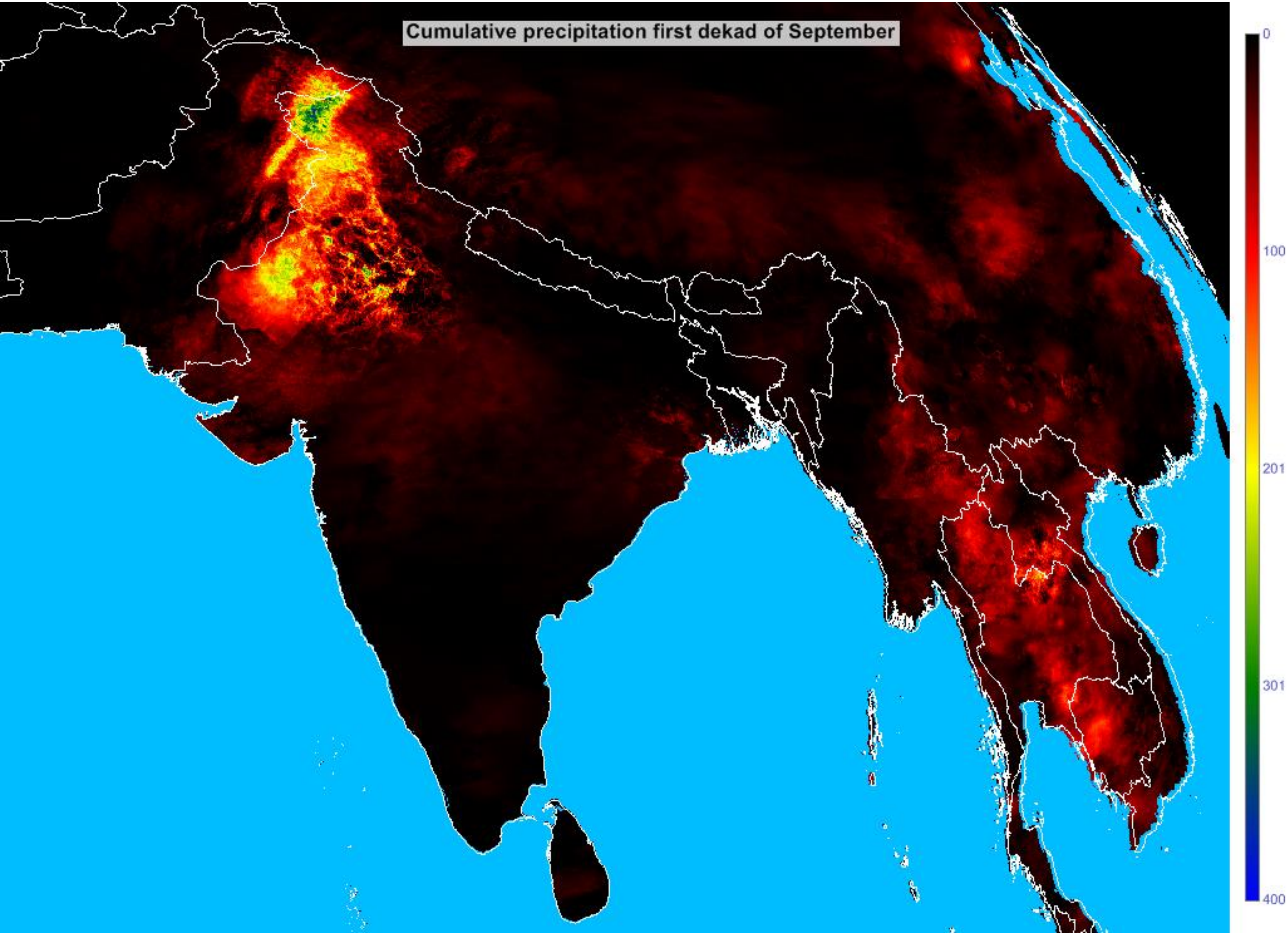
Meteosat Indian Ocean Coverage




Precipitation
September 2014 first dekad
0
25
50
75
100


Cumulative precipitation first dekad of September
0
100
201
301
400


Cumulative precipitation first dekad of September
0
100
201
301
400


Cumulative precipitation first dekad of September
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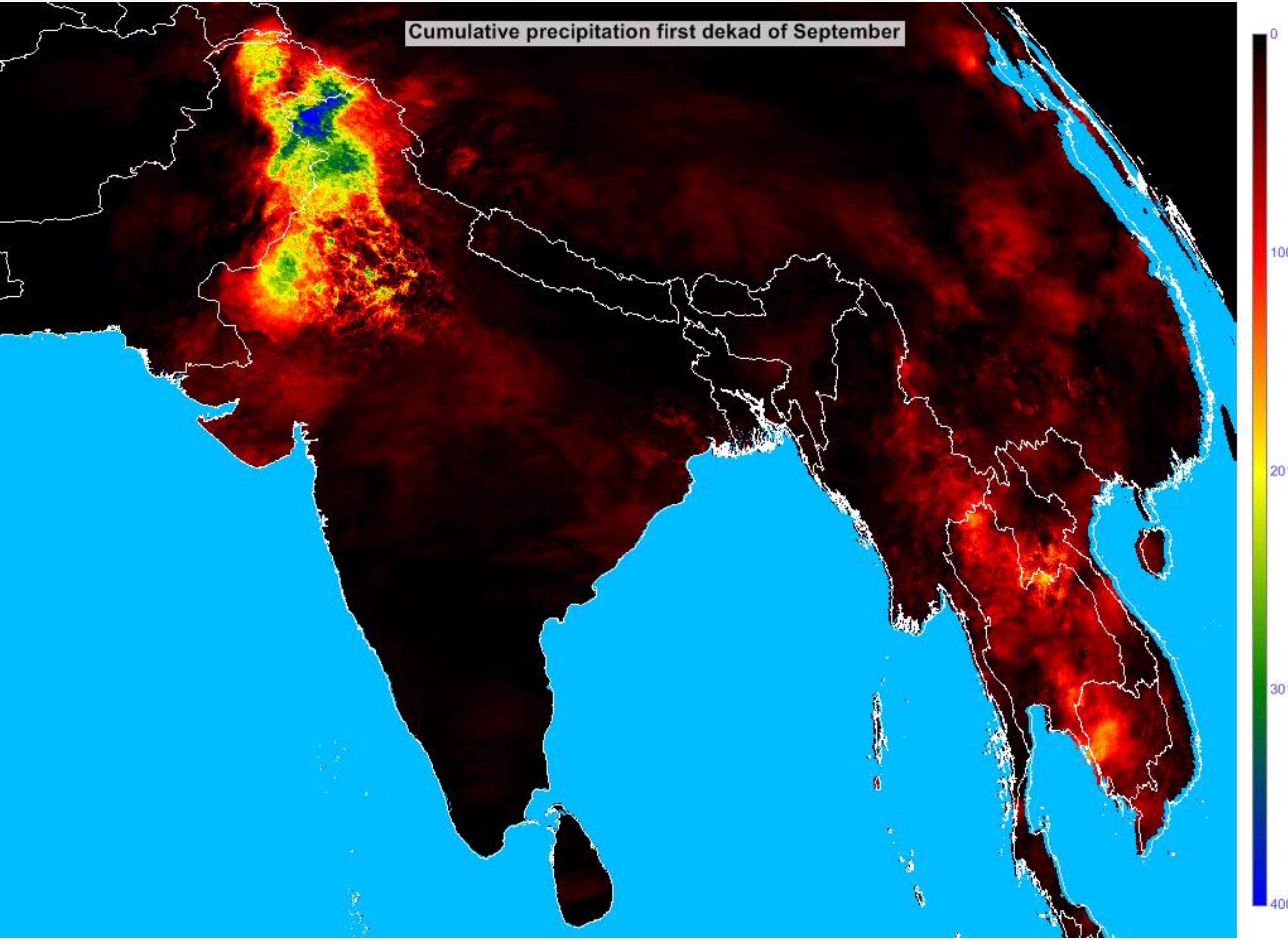
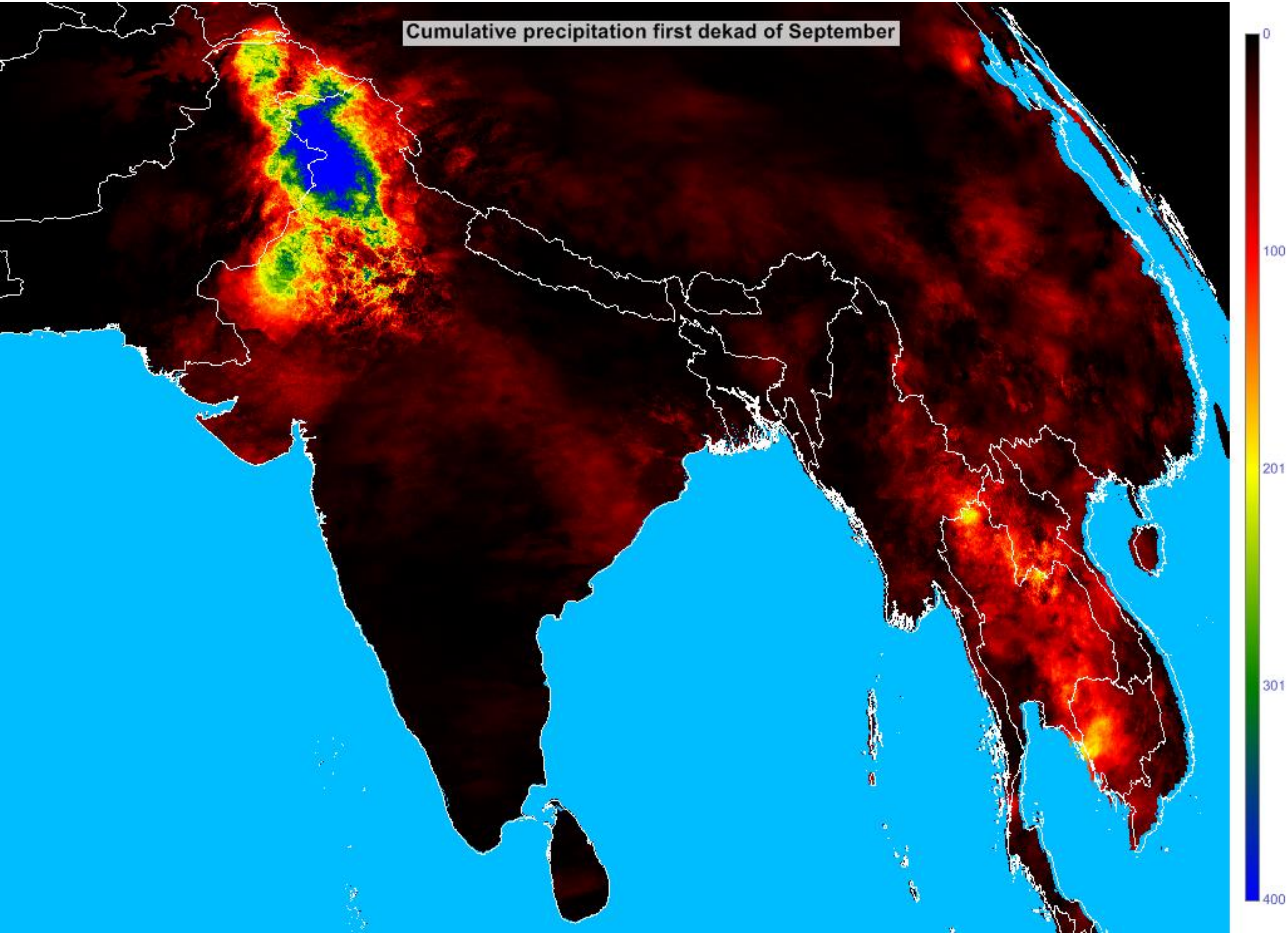
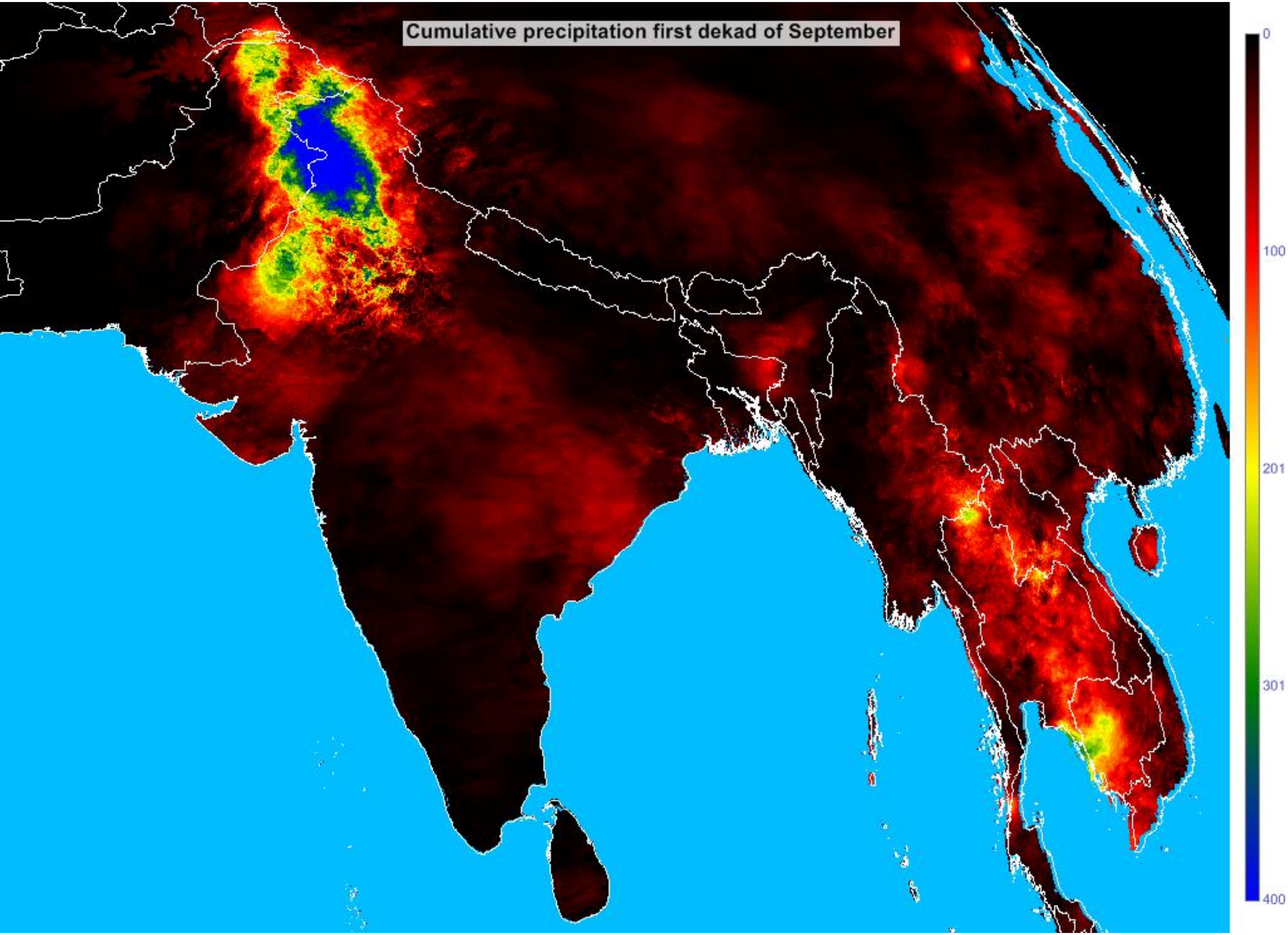
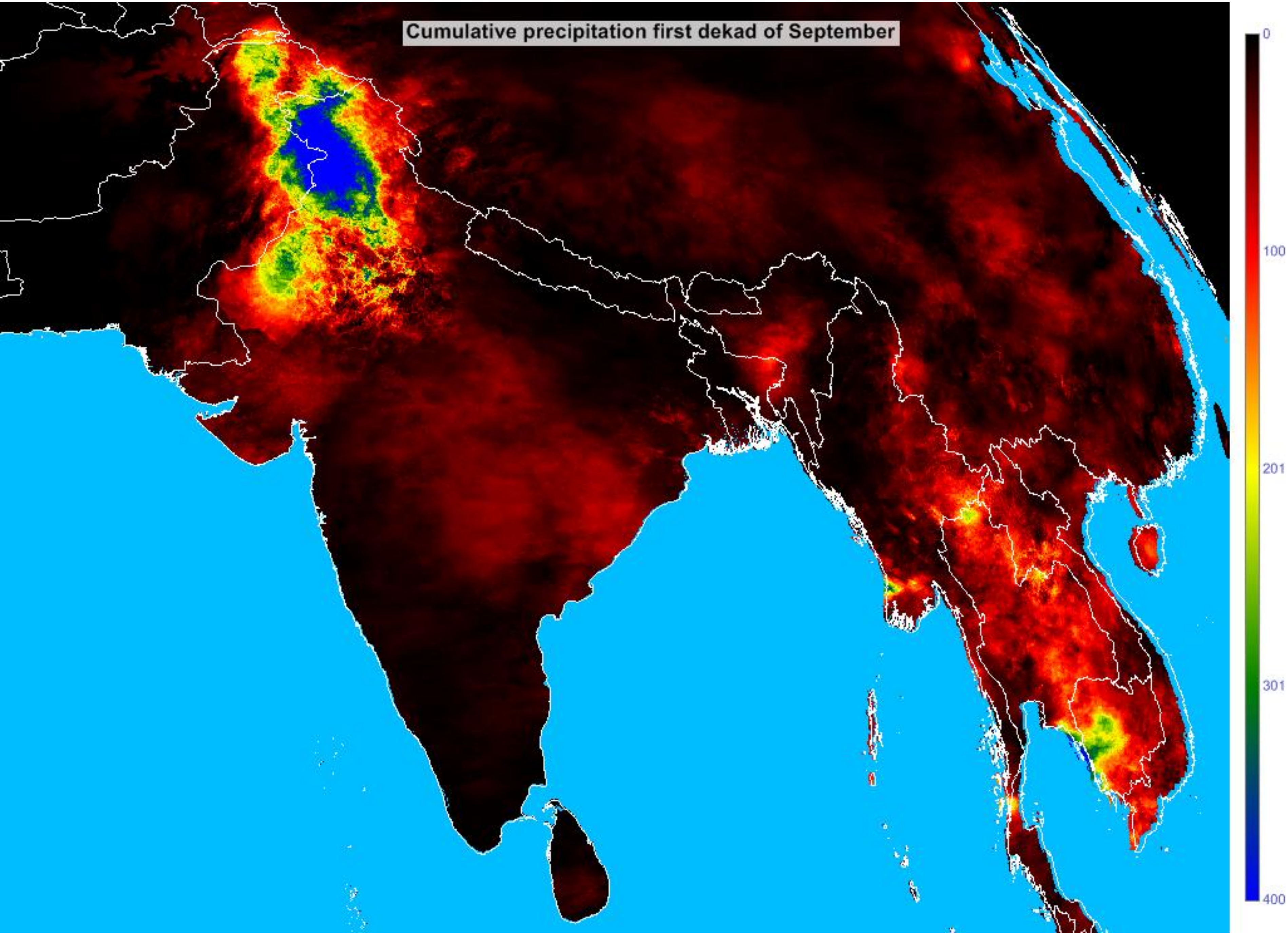
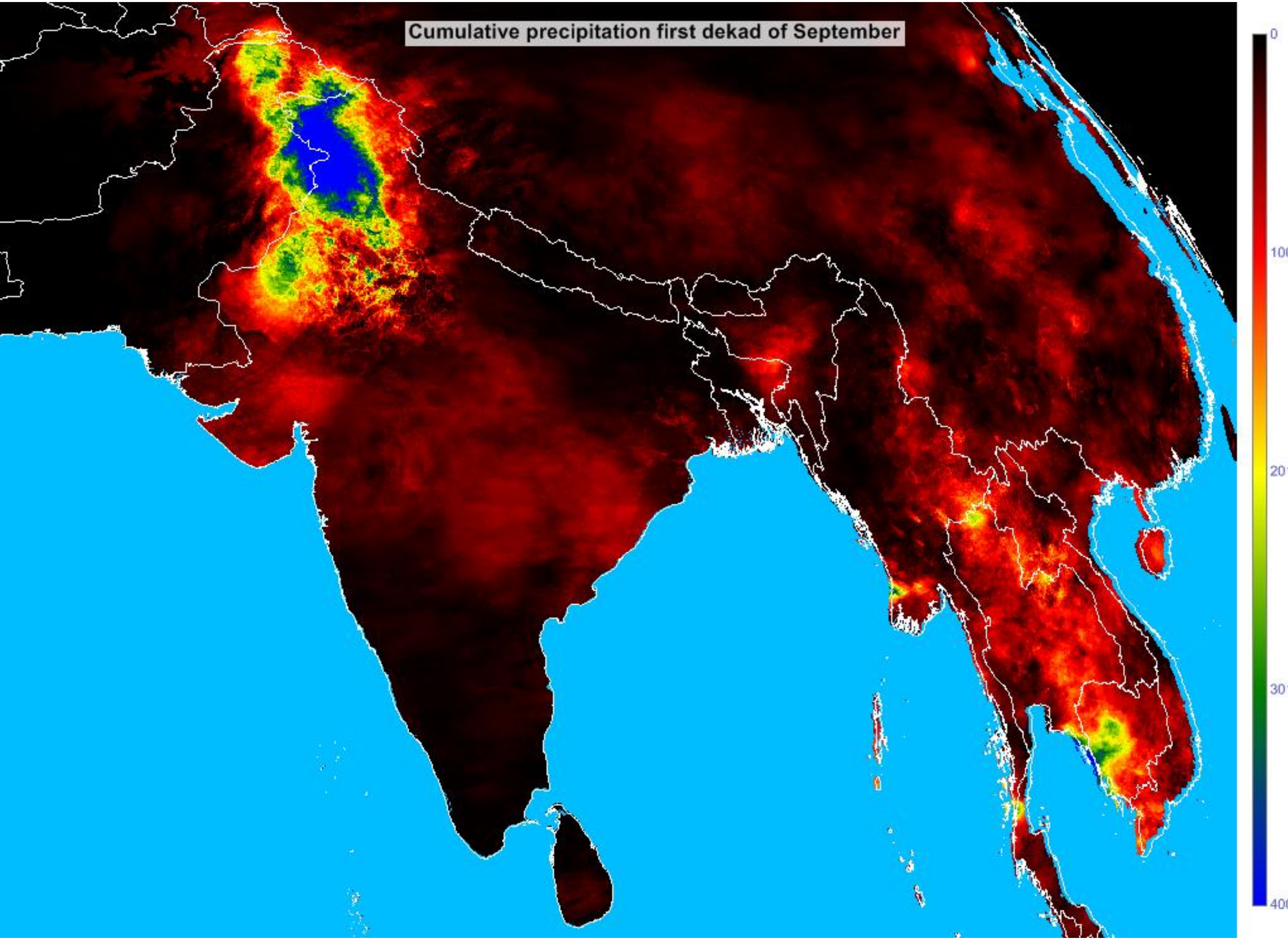
100
201
301
400

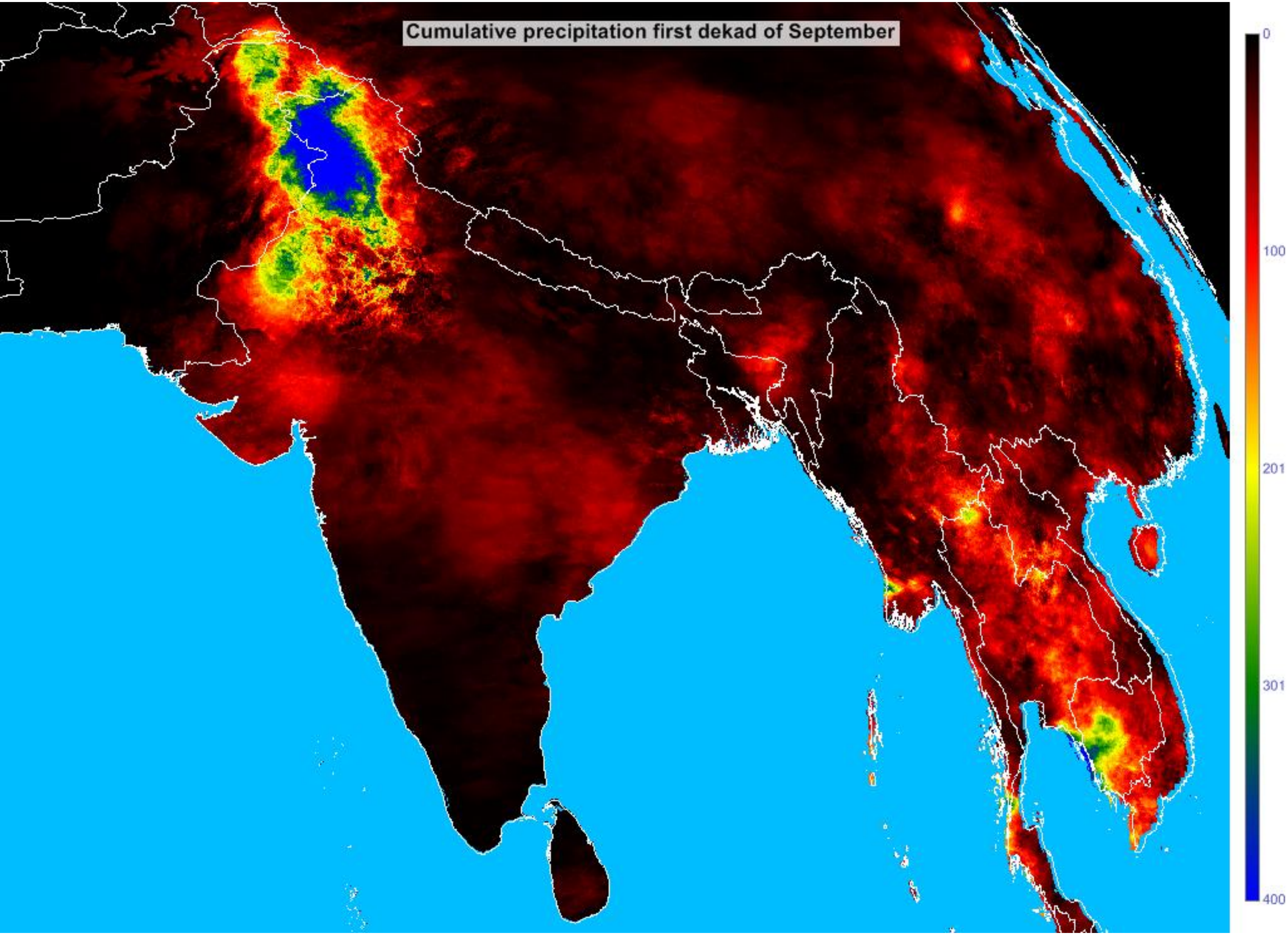

Cumulative precipitation first dekad of September
0
100
201
301
400


Cumulative precipitation first dekad of September
0
100
201
301
400


Cumulative precipitation first dekad of September
0
100
201
301
400


Cumulative precipitation first dekad of September
0
100
201
301
400


Cumulative precipitation first dekad of September
0
100
201
301
400


Cumulative precipitation first dekad of September
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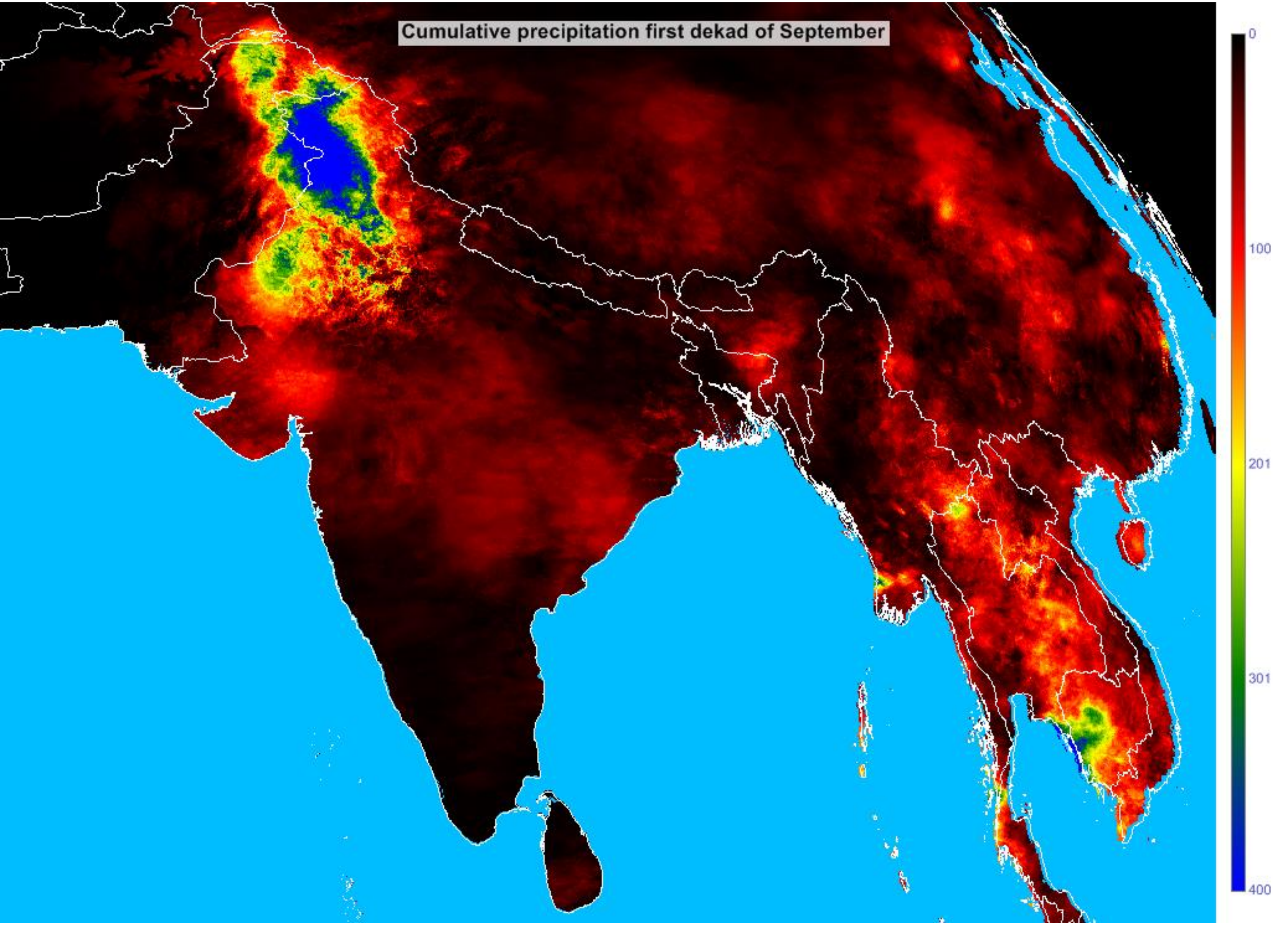
Cumulative precipitation first dekad of September
0
100
201
301
400

Thank you for your attention

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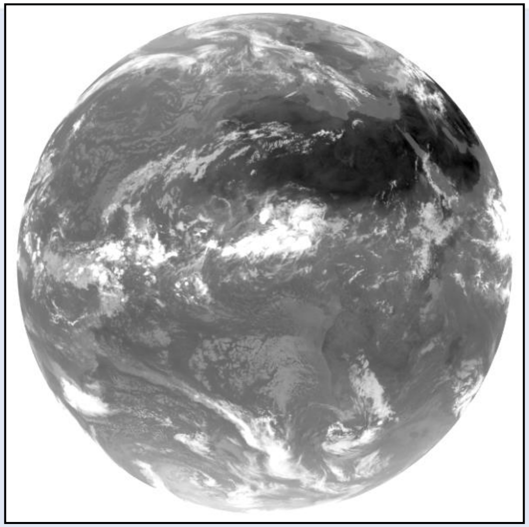
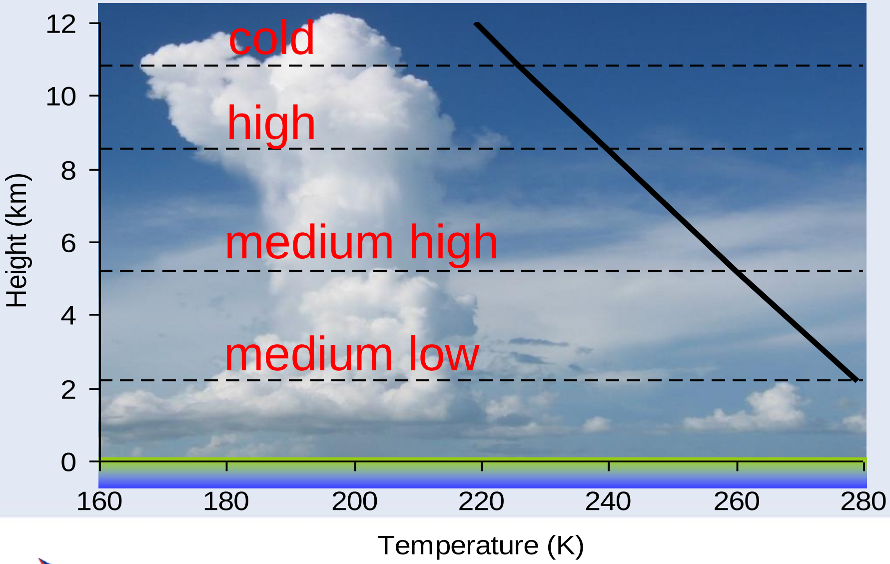
www.ears.nl

Rainfall processing





- Meteosat TIR
- Cloud top temperature
- Cloud level
- Cloud level durations (CD_i)
- GTS rain gauge data (R)
- Regression:

$$R = a_0 + a_1 CD_1 + a_2 CD_2 + \ldots.$$

- Calculate rainfall field

Evapotranspiration processing